

**Fungi parasitic upon Scale - Insects  
(Coccidæ and Aleurodidæ): a  
general account with special  
reference to Ceylon Forms.**

BY

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(*With Plates I. to IV.*)

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**CONTENTS.**

- I.—Introductory and Historical.
  - II.—Systematic Account.
    - (A) Ascomycetes.
    - (B) Fungi-imperfecti.
  - III.—General Remarks.
  - IV.—Summary.
  - V.—Table of Species with their Hosts, &c.
  - VI.—Bibliography.
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*I.—INTRODUCTORY AND HISTORICAL.*

WHILE occupying the post of Scientific Assistant to the Director of the Royal Botanic Gardens, Peradeniya, in 1898-99, Mr. E. E. Green, author of "The Coccidæ of Ceylon" and Government Entomologist for the Island, brought to my notice various types of fungous growths on scale-insects, and desired me to take up their study. To him I am indebted for most of the material, and also for kindly naming the insects upon which the different fungi were growing. My thanks are also due to Mr. Macmillan, the

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Curator of Peradeniya Gardens, for two excellent examples found by him in the jungle around Pussella.

A number of specimens were briefly examined in the laboratory at Peradeniya during my sojourn in Ceylon. On my return to England the material brought home was investigated in greater detail, and the literature upon the subject consulted. The results were communicated to the British Association in 1900 in a paper\* read before the Botanical Section.

Since then from time to time Mr. Green has sent me additional examples of these fungi as well as one or two new kinds. The publication of a full account of them has been delayed with the hope of obtaining further material for the elucidation of some of the more obscure forms, and also with the desire of incorporating the results of some culture and infection-experiments. However, as Mr. T. Petch, the newly appointed Mycologist to the Peradeniya staff, is proposing to take up the study of the group, it seems now desirable to place on record an account of the various forms that have passed through my hands, and at the same time to bring the subject up to date by referring in a general way to the species which have been described for other countries, hoping thereby to render some assistance to my successor.

The literature on the subject is not extensive, though it is necessary to go back as far as 1848 for the first reference. In that year Desmazières† described a new fungus in the conidial stage growing upon the scales of a coccid on young willow-stems in France. He proposed a new genus of the Fungi-imperfecti, *Microcera*, to receive this conidial form. Since then this fungus has been proved to be the conidial fructification of a species of *Sphaerostilbe*, and has been shown to have an extensive distribution on scale-insects in both the old and new worlds.

Till comparatively recently no other papers of importance have appeared on the subject. Such a position for certain

\* Report, Brit. Assoc. Bradford Meeting, 1900, p. 932. (Abstract.)

† Desmazières, Ann. des. Sc. Nat., 1848, p. 359.

species of fungi has been mentioned incidentally from time to time in systematic treatises. References to these occur in the descriptive part of this paper.

Within the last twelve years some of the Experiment Stations of the Agricultural Department of the United States of America have been interesting themselves in these fungi, especially from the economic standpoint. Webber\* in 1897 in an important paper on the "Sooty Mold of the Orange and its Treatment" describes certain entomogenous fungi which indirectly can assist in the removal of "sooty mould" (*Meliola*) by attacking the coccids which excrete the honey-dew. It is upon this sugary excretion that the *Meliola* grows clogging the leaves and spoiling the appearance of the fruit. So not only does the scale-pest inflict direct damage on the orange trees by sucking its sap, but indirect harm as well by encouraging this unsightly *Meliola*. Webber chiefly deals with a fungus new to science and named by him *Aschersonia aleurodis*, parasitic upon the mealy wing or white fly (*Aleurodes*† *citri*) which is responsible for much sooty mould on the orange in Florida. Other species of *Aschersonia* are mentioned, as well as a sterile form named for the purpose of convenience, the "brown mealy wing fungus." This genus *Aschersonia* is largely represented on species of *Aleurodes* in Ceylon. Rolfs‡ in the same year published an account of fungous disease on the San José scale (*Aspidiotus perniciosus*) and shows that it can be used to check this great pest. The fungus appears to be the *Microcera* originally discovered by Desmazières. Two years later inoculating experiments carried out in Illinois with this fungus on the same insect are described by Forbes.§ He thinks,

\* Webber: U.S.A., Depart. Agric., Div. of Veg. Physiol and Pathol. No. 13, 1897.

† The genus *Aleurodes* does not strictly belong to the family Coccidæ, but to the allied one Aleurodidæ. In this paper the term "scale-insect" includes members of both families.

‡ Rolfs, Florida Agric. Exp. Station, Bull. 41, 1897.

§ Forbes, Illinois do. do. 56, 1899.

however, the fungus will probably not be able to keep down the scale without the aid of artificial insecticides as well. Gossard\* follows with a paper containing observations and experiments with this fungus on the San José scale in Florida. He says it has developed so vigorously in some localities as to render insecticides unnecessary. It is believed that at least during warm rainy weather the fungus is quite capable of keeping the insect in check. A point to be noticed is that kerosine and such like insecticides not only destroy the scale but its fungous parasite as well, while fumigation with hydrocyanic acid does not affect the latter. The same author† about a year later refers to the natural enemies of the white fly (*Aleurodes citri*), including *Aschersonia aleurodis* and the brown sterile fungus, originally brought to notice by Webber. Such are in brief the observations and experiments that have been made in the United States on fungi parasitic on scale-insects. The various publications demand close study from those who are interested in the economic aspect of the subject.

In Natal *Microcera coccophila* (ascus-stage *Sphaerostilbe coccophila*) has been observed by Fuller‡ to be common on the red scale (*Aspidiotus aurantii*). In a wet summer, he says, it makes much headway against the coccid.

Quite recently McAlpine§ has described species of *Microcera* on scale-insects in Australia. He hopes to conduct inoculating experiments with those.

A different type of fungous parasite to the above was observed by Zimmermann in Java in 1897 on the green bug (*Lecanium viride*), one of the most dangerous enemies of the coffee shrub. In the following year he published a short paper|| for the benefit of the Java planters, pointing

\* Gossard, Florida Agric. Exp. Station Bull 61, 1899.

† Gossard, Florida do. do 67, 1903.

‡ Fuller, 1st. Report of Govt. Entomologist, Dept. Agric. Natal, 1901, p. 99.

§ McAlpine, J. Dep. Agric.: Victoria, vol. II., Pt. 7, 1904, p. 646.

|| Zimmermann, Over een Schimmel epidemie der Groene Luizen, Buitenzorg, Java, 1898.

out that cultures of this fungus might be employed as a check against this insect, and suggesting how experiments might be carried out. He refers the fungus to *Cephalosporium* and names it provisionally *C. Lecanii*. Numerous examples identical with this have been found in Ceylon. Since then the same author has described\* systematically several Ascomycetous fungi belonging in the main to the group Hypocreales, parasitic on scale insects in Java; these will be referred to in detail under their respective genera.

Guégnent† in an exhaustive work on fungous parasites of man and animals published last year gives an account of a new conidial form, *Acrostalagmus coccidicola*, found by him on a coccid in a greenhouse in Paris.

The most recent contribution to the subject is a paper by Dop‡ on a new fungus parasitic on *Aspidiotus* from Martinique. The advent of the fungus has practically saved the cocoanut palm cultivation in this Island. The author refers it to the genus *Hyalopus*; thus it is probably near akin to *Cephalosporium*.

Previous to the stimulus given by Mr. Green to the study of these fungi, the Ceylon forms had received no attention. The only mention of such a position for a Ceylon fungus occurs in a systematic paper by Berkeley and Broome§ on some fungi received from the Island. A species of *Nectria* is named as apparently growing from some coccus.

In the present paper the various fungi associated with scale-insects are taken in systematic order. The ones which have been described elsewhere by different observers are referred to briefly, and then the Ceylon forms similar to these are treated at some length and compared with them. Though an attempt is made to discriminate between species,

\* Zimmermann, Centralb. f. Bakt., Abth. II., Bd. VII., 1901, p. 872.

† Guégnen, Les champignons parasites de l'homme et des animaux, Paris, 1904, p. 252.

‡ Dop, Bull. Scient. France et Belgique, XX XIX., 1905, p. 135.

§ Berkeley and Broome, Journ. Linn. Soc. XIV., 1875, p. 117.

no diagnosis of new ones has been undertaken, as this on the one hand is more the work of a specialist, and, on the other hand, their investigation is not sufficiently advanced to permit of this. A hasty formation of new species, specially of fungi, is to be deprecated. It seems preferable to err rather in the opposite direction, grouping together forms presenting slight differences, till further study warrants them being split into distinct species. Small deviations in size, shape, or colour, unless definitely shown to be constant, do not appear to be sufficient for the separation of species of taxonomic value. Colour as a systematic character should be used with caution, because it can alter with age, and has often faded in material, the examination of which has been postponed for some time after its collection. Then again no two observers are likely to describe the same tint in exactly the same words. So in order to arrive at uniformity in systematic colour descriptions a standard chromatic scale should be used as recommended by Guégnen.\*

The recognition of what are called "biological species" amongst parasitic fungi renders still more difficult the separation of what should rank as taxonomic ones. To take a hypothetical case, the *Microcera* on *Aonidia* differs in certain external features from that on *Aspidiotus*; this is perhaps accountable for through a difference in the general structure of these coccids. If, however, the *Microcera* on *Aonidia* should be shown to be incapable of directly affecting *Aspidiotus*, would it be then justifiable to separate the two forms of this fungus as distinct taxonomic species?

All these scale-fungi are either complete Ascomycetous forms or incomplete conidial ones. The former are described first. The latter are provisionally placed in the Fungi-imperfecti, an artificial group the individuals of which are generally considered as conidial stages of various Ascomycetes. But as their ascus-fructifications are as yet unknown they cannot with any degree of certainty be classified with them.

\* Guégnen, *loc. cit.*, p. 9.

The measurements recorded for the various parts of the fungi about to be described are given either in millimetres (mm.) or in micromillimetres\* ( $\mu$ ).

The paper is illustrated by figures to aid the verbal descriptions. These have been either made directly from the specimens or copied from coloured drawings executed by Mr. Green and W. de Alwis, late draughtsman of the Royal Botanic Gardens, Peradeniya. It is to be hoped that these coloured drawings now in the possession of the author, with additions, may eventually be published with a complete account of the Ceylon coccidophagous fungi.

## II.—SYSTEMATIC ACCOUNT.

### (A) ASCOMYCETES.

#### *Pyrenomyces-Hypocreales.*

#### Genus *Torrubiella*, Boudier.

This genus was founded by Boudier† in 1885 for a fungus named *T. araneida*, discovered by him on spiders in France. Since then three other species have been added, viz.:—

*T. tomentosa*, Pat.,‡ 1892, on a spider (?) on a leaf of a tree, Ecuador, S. America.

*T. rubra*, Pat.,§ 1893, on the dead bodies of a coccid, on leaves of *Melastoma* sp. and *Solanum* sp., Ecuador, S. America.

*T. luteorostrata*, Zimm.,|| 1901, on a coccid on a leaf of a jungle tree, Java.

This genus is characterized by forming a dense hyphal mat, upon the margin of which are borne several upright elongated perithecia. The ascospores are thread-like. Thus it is fairly sharply marked off from the rest of the

\* A micromillimetre equals 0.001 mm.

† Boudier, *Revue Mycol.* 1885, p. 227 : and Saccardo, *S. F. Addit.* to vol. I.-IV., 1886, p. 220.

‡ Patouillard et Lagerheim, *Bull. Soc. Mycol. France*, VIII., 1892, p. 133.

§ Patouillard et Lagerheim : *Bull. Soc. Mycol. France*, IX., 1893, p. 151.

|| Zimmermann, *loc. cit.*

Hypocreales with the exception of Globulina. The species so far discovered we see are entomogenous or rather restricted to spiders and coccids. The species for which the genus was originally founded possessed peculiar sterile hyphæ mixed with the asci, known as paraphyses. These are absent in the three species since added as well as in the Ceylon forms. The presence of paraphyses is given in "Die Pflanzenfamilien"\* as a distinguishing character, separating it from Globulina. This now requires alteration.

*Ceylon Forms.*

The Ceylon specimens found on three occasions may perhaps be separated into two distinct species.

*Type 1, resembling T. rubra and T. luteorostrata.*

(a) On *Aleurodes*, sp.,† on the lower surface of leaves of *Tetranthera*, sp., found by Green in the jungle Pundalu-oya. February, 1899 (fig. 1).

The fungus forms over and around the insect a compact brown circular mat or pustule of hyphæ almost deserving the name of stroma. It is thickest in the middle and gradually thins out towards the periphery where it is succeeded by a fine white hyphal fringe extending for some distance over the leaf-surface. The brown pustules have a diameter of 1.5-2 mm. and the white part a breadth of about 1-1.5 mm. The long somewhat flask-shaped or conical perithecia are borne erect on the hyphal fringe and are conspicuously coloured objects. The lower bulbous part is bright pink; this colour then gradually deepens upwards, so that the apical part of the neck is nearly black. They stand separately; a few, such as five, around each pustule. The perithecium (fig. 2) measures  $825\ \mu$  long; its lower bulbous part  $225\ \mu$  and upper neck part  $140\ \mu$  broad. The ascus ( $380 \times 8-9\ \mu$ ) contains eight thread-spores ( $300 \times 2-4\ \mu$ ) somewhat guttulate but not septate (figs. 3 and 4).

\* Engler and Prantl, Teil I., Abtheil. I., p. 347.

† The Ceylon species of *Aleurodes* have not yet been classified. Mr. Green hopes to monograph the Aleurodidae of the Island after he has completed the true coccids.

(b) On *Aleurodes*, sp., on lower surface of leaves of a jungle tree collected by Macmillan, Pussella, February, 1899.

This specimen was most likely an older stage of (a). The stroma-like mats covering the insects had here and there a distinct red colour. Some of them were as much as 4 mm. in diameter. The perithecia were similar to (a), but more numerous, while ascus and ascospore were identical.

*Type 2, resembling somewhat T. tomentosa.*

On *Aspidiotus destructor* on lower surface of leaves of a jungle tree, found by Green, Pundalu-oya, 1899 (fig. 5.)

This type differed from the foregoing chiefly in the colour of its perithecia. These were pale yellow-brown with gelatinous-looking apices. As many as nine were counted around a pustule, either occurring singly or in groups of two or three with coherent bases. The perithecia on the whole were smaller, measuring in length  $525\mu$  and in breadth, lower part  $225\mu$ , neck  $75\mu$ . Ascus and spore similar. The whole fungus has a softer and whiter appearance to the preceding type and occurs on quite a different kind of scale-insect.

The differences between *T. rubra*, *T. luteorostrata*, and the red Ceylon form are very slight. Zimmermann says the Java species differs from *T. rubra* through its perithecia being smaller, having yellow ostioles and in many being grouped on one stroma.

No conidial stage has been found as yet associated with the Ceylon specimens, nor are any described by Patouillard and Zimmermann. Boudier\* in 1887 discovered a conidial fructification (*Isaria cuneispora*) belonging to *T. arani-cida*.

Genus *Nectria*, Fries.

The first material handed to me by Mr. Green consisted of scales of *Aspidiotus* attacked by a red fungus on twigs of a Citrus shrub. This was in the conidial condition and

\* Guégnen, *loc. cit.*, p. 183.

referable to *Fusarium*. Later deep pink perithecia appeared, clearly revealing the fungus to be a *Nectria*. Further search has shown it to be one of the commonest of the Ceylon scale fungi, attacking exclusively coccids belong to the sub-family Diaspidinae.

In a systematic account of some Ceylon fungi published in 1875 by Berkeley and Broome\* a new species of *Nectria*, named *N. aurantiicola*, is mentioned incidentally as growing apparently from some coccus on orange twigs. This naturally suggests the possibility of *N. aurantiicola* being identical with the one first discovered by Green. It will be shown, however, that Berkeley and Broome's *Nectria*, judging from their description, does not agree in every detail with the one recently found. Still the disparity is perhaps hardly sufficient to separate the two forms as distinct species.

Two instances of *Nectria* occurring on coccids are recorded in Saccardo's "Sylloge Fungorum." The first *N. coccorum* Speg.,† was found in Brazil, and is described as growing on dead coccids situated on fallen leaves. No conidial fructification is mentioned. It is placed in the sub-genus *Dialo-nectria* and distinguished as having smooth solitary perithecia and no stroma, whereas *Eu-nectria* possesses one.

The second, *N. coccigena* (*Eu-nectria*), Speg.,‡ was also found in Brazil growing on dead coccids on living leaves of a species of *Eugenia*. No description of the fungus is given in Saccardo's work.

A more important instance of such a position for *Nectria* is that of Zimmermann. In his paper§ of 1901 on Java forms of Ascomycetes parasitic on Coccidæ, he describes a species of *Nectria*, which he considers new and names *N. (Eu-nectria) coccidophthora*. He says it is closely related to *N. aurantiicola*, Berkeley and Broome, but differs in the

\* Berkeley and Broome, *loc. cit.*

† S. F. additamenta to vols. I.-V., 1886, p. 205.

‡ S. F. vol. IX., 1891, p. 259.

§ Zimmermann, *loc. cit.*

colour of its perithecia and slightly in details connected with its conidial stage. It seems, however, identical in every way with the common Ceylon scale-Nectria. The Java examples were found on *Mytilaspis*, sp., on *Coffea arabica* and on *Parlatoria zizyphi* on Citrus, Buitenzorg.

1.—*Ceylon specimens considered identical with Nectria coccidophthora*, Zimm.

*Conidial stage* (Fusarium) fig. 6.

Several bright orange-red club-shaped or columnar bodies appear standing up around the rim of the scale. Each consists of a short stout stalk and a conspicuous waxy-looking head (figs. 7 and 9). Sometimes the stalk is almost suppressed. It consists of hyphæ massed together, and is all that can be regarded as stroma. The head is composed of conidia and the special hyphæ (conidiophores) which bear them, arranged parallel to one another. The conidia are all held together in a compact mass by soluble mucilaginous matter. On treatment with water the head rapidly swells, releasing the conidia which float away (fig. 10).

Since the word stroma is sometimes employed loosely, it is well to be clear as to its meaning here. A lax irregular arrangement of hyphæ is termed a mycelium. Fructifications, *i.e.*, special spore-producing structures, may be borne directly on the mycelium; but often the hyphæ first become thickly massed together and much septated to form a compact tissue often pseudoparenchymatous in structure—the stroma—upon or within which the fructifications appear. In the case of this *Nectria* little of this special compact tissue or stroma is developed. It is merely represented by the stalks of the conidial cushions.

Conidiophores may occur separately or be joined together into compound bodies. In this fungus they are conglutinated into a wax-like head, to which the name sporodochium\* has been applied.

\* Massee, British Fungus Flora. vol. III., 1893, p. 270.

Neither stroma nor to any extent has mycelium been noticed covering the external surface of the scale. Zimmermann\* speaks of the stroma of *N. coccidophthora* as being shortly stalked, using the word here evidently as equivalent to sporodochium.

The stalk of the sporodochium varies considerably in length; the extremes met with were 1.2 and 0.15 mm. Very commonly the length is 0.2 to 0.3 mm, with a breadth of 0.15 to 0.3 mm. Zimmermann\* gives the length of the stalk from 0.3 to 0.4 mm.

The head is more constant in its proportions, about 0.4-0.5 mm. long by 0.25-0.4 mm. broad, agreeing closely with Zimmermann's figures for length, viz., 0.4-0.45 mm. He says the head is enveloped in a sheath of sterile hyphæ connected together sideways by ladder-like cross-pieces. In the Ceylon specimens this sheath is also present. It can easily be overlooked, as it adheres closely to the conidial mass and is not readily distinguished from the conidiophores themselves. It consists of parallel septate hyphæ, stouter than those bearing the conidia ( $3\mu$  compared with  $2\mu$ ). At long intervals hyphæ adjacent to one another are connected by narrow and extremely short cross-pieces ( $1.3 \times 1.4\mu$ ). A distance of  $70\mu$  may occur between two successive connections (fig. 13).

The conidiophores are filiform; at any rate they do not bifurcate in the upper part (fig. 12). They may branch a little near the base.

The conidia are long, multiseptate, and slightly curved with somewhat falcate ends (fig. 11). The septa vary in number; extremes met with were 5 and 10, 9 is about the average, though 7 is very common. This variation may be partially accounted for through differences in age. Average length  $90\mu$ . Some measured as much as  $104\mu$ , and others as little as  $68\mu$ . Breadth  $6-9\mu$ . Zimmermann's numbers for septa are 7-9, and for measurements  $110-120\mu \times 6\mu$ . Thus the conidia of the Java form appear to

\* Zimmermann, *loc cit.*

be somewhat longer. Berkeley and Broome's species, *N. aurantiicola*, is described as having multiseptate conidia  $94\mu^*$  long, very near the above average for the Ceylon *N. coccidophthora*. A smaller variety of conidium is also mentioned by these authors, only 3-septate and  $20\mu$  in length. Such have not been found as a distinct feature of any of the sporodochia examined by me. There is the possibility of these shorter and less septated conidia being immature.

*Ascus-stage.*

The perithecia appear later grouped around the stalks of the old and disappearing sporodochia. Thus both types of fructification may be considered as borne on a feebly developed stroma (fig. 8). As many as seven perithecia have been counted clustered round the stalk or base of a sporodochium. They are deep pink nearly spherical bodies with an average diameter of  $200-225\mu$ . The ascus is of the usual *Nectria* pattern ( $120 \times 9\mu$ ) (fig. 15). The two-celled oval ascospore measures  $12-15 \times 7-9\mu$  (fig. 16). The perithecia described by Zimmermann are very similar. His measurements make the perithecium rather bigger and the ascospore somewhat longer. Those of *N. aurantiicola* are also very similar, except in colour which is given as orange.

This Ceylon *Nectria* has been collected by Mr. Green and the author on five species of coccids belonging to three genera, all included in the Diaspidineæ. Further details respecting these specimens are to be gathered from the Table at the end of the paper.

Till a comparison can be made with fresh examples of the Java species it does not seem at all advisable to make a new species or even variety of this common Ceylon *Nectria*. My own observations and measurements differ so little from those of Zimmermann that at present I am

\* In their paper (*loc. cit.*) the measurements are given in fractions of the inch. They have been converted into the metric scale for the sake of comparison.

inclined to regard the two as identical, especially as they both occur on the same type of scale-insect.

Relative to *N. aurantiicola* it is a point of some significance to remember that it was formed on orange twigs and appeared to be on a coccid. The above *Nectria* first discovered by Green has often been found on stems of *Citrus* spp., trees largely frequented by the Diaspidineæ. It thus seems possible that *N. aurantiicola* described by Berkeley and Broome may have been the same fungus. A difference in colour of the perithecia is not to be trusted if the material was examined some time after it was collected. The deep red of such perithecia may have faded.

As regards the Brazilian species, *N. coccorum* and *N. coccogena*, enumerated in Saccardo's *Sylloge Fungorum*, the first one is described as having orange-red perithecia, a point of distinction if this was the colour of the fresh specimens; its ascospores are also considerably longer. No conidial fructification is mentioned. I have not been able to see a description of the second one.

Before passing on to the next genus, a form of *Nectria* found on one occasion only and differing somewhat from the above deserves some notice.

2.—*Nectria*, sp., differing slightly from 1.

A bamboo bush growing in the nursery of the Royal Botanic Gardens, Peradeniya, in December, 1898, was infested with scale, upon which were growing two kinds of fungi. The scales on the upper surface of the leaves were attacked by a *Nectria*, and those on the lower side by a gray mould (*Verticillium*).

Some uncertainty existed as to the exact species of bamboo. The Curator informed me that it was perhaps *Bambusa Oliveriana*, Gamble. He thought it had come along with others from Calcutta, and as it always had a sickly look it had not been removed from the nursery. Mr. Green identified the scale as *Asterolecanium miliaris*, and was surprised to receive it, as he had not come across this insect

in the Island before. Hence it is just possible that this coccid with its fungous parasites had been imported from India upon the bamboo.

The Nectria as already pointed out occurred invariably on the upper surface of the leaves. Some of the scales thus situated were covered with a thin white mycelium. From beneath them protruded light red bodies, the sporodochia. On older leaves deep pink nearly spherical bodies, the perithecia, were found similarly placed, instead (fig. 17).

*Conidial stage* (Fusarium).—The pale red sporodochia had practically no stalk (stroma). They did not stand erect, but grew out horizontally for a short distance (about 0.18 mm.) from the rim of the scale. Two or three were usually the number to a single scale, but as many as five were seen. Often one, resembling a fish-tail, protruded from the posterior end of the insect (fig. 18).

The conidia were similar to those of *N. coccidophthora* already described, and measured  $100-110 \times 5.5-7.5\mu$ . Their septa varied from 5-9.

*Ascus-stage*.—The perithecia occurred solitary or in groups of 4 or 5. They were broadly ovate in shape and bright pink in colour, measuring  $255\mu$  in height and rather less in breadth. The ascus of the usual type measured  $115 \times 13.5\mu$ ; the ascospore, elliptical and somewhat pointed,  $22-27 \times 9-10\mu$  (fig. 19).

In no marked feature except in general appearance does it differ from the common Ceylon form. Its sporodochia are not so prominent, do not stand erect, and have no stalk; but the conidia themselves are almost identical. The perithecia and asci are also very similar, but the ascospore is distinctly larger. In this latter respect it agrees more closely with the description of *N. coccorum*\* which has ascospores measuring  $22-25 \times 5\mu$ . It also corresponds with this species by having its perithecia solitary or in small groups, and by the absence of stroma.

\* Saccardo, S. F. Addit to vols. I.-IV., p. 203.

The subgenera *Eu-Nectria* and *Dialo-Nectria*, as already indicated, are distinguished from each other according to the presence or absence of a fleshy stroma, and as to whether the perithecia occur in clusters or solitary. This is a somewhat arbitrary distinction, at any rate as far as these scale Nectrias are concerned. One and the same species might be placed with equal justification, in either subgenus. Lindau, in "Die Pflanzenfamilien"\* says the genus requires monographing, since the alleged subgenera are insufficiently marked off from one another.

It is to be noted that this bamboo Nectria was growing on a scale belonging to a different sub-family, the Lecanodiaspidinæ.

As already pointed out, a curious feature about the scales on this bamboo was the restriction of the Nectria to those on the upper surface of the leaves. On those of the lower side occurred a *Verticillium*. This will be referred to in detail under the Fungi-imperfecti. It may possibly be connected with the Nectria. *Verticillium* is known as a conidial stage of a Nectria.†

Genus *Lisea*. Sacc.

This genus differs from Nectria in having blue or violet perithecia instead of red ones. A new species, named *L. Parlatoria*,‡ has been described by Zimmermann, parasitic on a scale-insect. It was found at Buitenzorg, Java, on *Parlatoria zizyphi* on Citrus leaves. No conidial stage is mentioned. The genus is known to have one of the *Fusarium* type. *Lisea* has not yet been found on scale-insects in Ceylon.

(?) Genus *Calonectria*, de Not.

On two occasions Mr. Green has supplied me with leaves infested with scale, on which were situated perithecia agreeing closely with those of *Calonectria*.

\* Teil I., Abtheil. I., p. 358.

† Saccardo, S. F., vol. II., p. 511.; *Nectria solani*.

‡ Zimmermann, *loc. cit.*

1.—*On Mytilaspis citricola on orange leaves.*

The perithecia occurred in groups, each resting on a small mat of hyphæ proceeding from the scale. No stroma was seen. They were pale brown in colour, globular in shape with a wort-like ostiole (pore), and measured  $217\mu$  in diameter. The ascus ( $70-84 \times 12-14\mu$ ) contained 8 spores somewhat irregularly arranged (fig. 20). The spindle-shaped ascospore (fig. 21) was conspicuously bisepate and less so 4-septate perhaps owing to immaturity and measured  $30-46 \times 6.5-7\mu$ . Its lower end, as situated in the ascus, tapered with a blunt point, the upper end being acute and sharp.

2.—*On Chionaspis vitis on leaves of Loranthus, sp.*

Similar to 1, but the perithecia were dark brown and seemed old;  $320\mu$  in diameter. The ascus measured  $85 \times 16\mu$ , and the spore  $55 \times 7.5\mu$ ; it was 5-septate (fig. 22).

No conidial fructifications were found in connection with either of these supposed Calonectriæ.

Genus *Ophionectria*, Sacc.

A fungus allocated to this genus and named *O. coccicola* (Ell. and Ev.) Berl. and Vogl.\* was found on a living coccid on the leaf of Citrus in Florida. Zimmermann† has discovered it in Java on *Parlatoria zizyphi*, and suggests the possibility of its having been imported from America. He describes the conidial stage of it for the first time. It has not been found as yet in Ceylon.

Genus *Sphærostilbe*, Tul.

The perithecia of *Microcera coccophila*, a conidial form first discovered on scale-insects by Desmazières,‡ were described by Tulasne§ in 1865 and named *Sphærostilbe coccophila*. Since then similar perithecia have been found connected with this *Microcera* in the United States. Though the conidial form is common in Ceylon, perithecia have not yet been found.

\* Saccardo, S. F., vol. IX., p. 996.

† Zimmermann, *loc. cit.*

‡ Desmazières, *loc. cit.*

§ Tulasne, *Carpologia*, vol. III., p. 105.

There seems to be some ambiguity as to the characters of the genus *Sphærostilbe*. In Lindau's scheme of classification of the Hypocreales (*Die Pflanzenfamilien*, Teil I., Abth. I., p. 347) the tribe Nectriæ is divided into two main divisions, viz., genera which have Stilbum-like conidial fructifications and those which have not. The former contains amongst several others the genus *Sphærostilbe*, while the latter includes *Nectria*. In other respects these two genera are alike. On this basis how can the above species be reckoned a *Sphærostilbe*, when it has the *Microcera* form of conidial fructification? Should it not be rather put in the genus *Nectria*? It seems to me in any case hardly justifiable to separate Ascomycetous genera merely on differences in their conidial fructification, especially as the same species may possess more than one type of conidiophore. To me it would be sounder policy to construct genera only on distinctive features in the ascus-stage and to use differences in the lower kind of fructification for subdivisions within the genus. Consequently I should be inclined to refer the species in question to the genus *Nectria*, and at the same time to incorporate with it the other species of *Sphærostilbe* as well, provided that no common feature can be found in the perithecium and its contents to distinguish these forms from those of *Nectria*. The scale-insect fungi of the conidial genus *Microcera* will be described in detail in the part devoted to the Fungi-imperfecti.

Genus *Broomella*, Sacc.

This genus is characterized by having its perithecia partially sunk in a fleshy stroma, but its ascospores are not thread-like as in *Hypocrella* and *Cordiceps*. A new species named *B. Ichnaspidis*, has been found by Zimmermann\* on a scale-insect, *Ichnaspis filiformis*, on leaves of *Coffea liberica* and *Elæis*, sp., at Buitenzorg, Java. Its ascospores are many celled (up to 16).

\* Zimmermann, *loc. cit.*

A larger form of this fungus has also been collected in Java and is described as a separate variety by this author.

Fungi referable to this genus have not yet been discovered on scale-insects in Ceylon.

Genus *Hypocrella*, Sacc.

This genus is one which may eventually be shown to be of common occurrence on scale-insects. It is characterized by having disc-shaped or hemispherical stromata in which the perithecia are sunk. Its thread-like ascospores often break up into sporules.

The species so far described have been found on leaf and stem surfaces in the tropics. Quite possibly in some of these cases a scale-insect is the real host and not the plant.

The conidial fructification, as far as is known, belongs to the genus *Aschersonia*—one which occurs frequently on scale-insects.

Zimmermann in his paper\* describes for the first time a new species of *Hypocrella* (*H. Raciborskii*), having as its host a scale-insect. It was found by Raciborski in Central Java on a coccid fixed to a Citrus leaf. It possesses a conidial fructification of the *Aschersonia* type. The conidial chambers (pycnidia) are situated in the lower part of the stroma whereas the perithecia are formed in the upper part.

A *Hypocrella* distinct from the above has been collected in Ceylon, showing no conidial fructification.

Though numerous examples of *Aschersonia* have been found in Ceylon, only in one have the stromata possessed perithecia as well as pycnidia.

A third example of a probable *Hypocrella* had a stroma not strictly referable to *Aschersonia*.

*Ceylon Forms.*

1.—On *Lecanium expansum* on the upper surface of leaves of *Schumacheria alnifolia*, Maskeliya, Sept., 1901 (fig. 23).

\* Zimmermann, *loc. cit.*

The bright orange stromata consisted of a thickened rim and a raised central crown, thus somewhat hat-shaped. The largest measured as much as 7.5 mm. in diameter: the medium ones 4.5 mm., and some of the small ones 2.5 mm. The rim is dotted over with dark brown spots, the openings of the perithecia; sometimes these spots may extend a short way up the crown. The colouring is not quite uniform, the rim being nearer red, and the crown nearer yellow. The interior of the stroma is light yellow.

The flask-shaped sunken perithecia measure 400–440  $\mu$  in depth and the narrow asci  $103 \times 7.3$  (fig. 24).

The ascospores were perhaps thread-like, but they had split up in short rods  $6-7 \times 1.5\mu$ .

No pycnidia could be observed in the stroma, so this latter was solely in the ascus-stage.

This *Hypocrella* is evidently quite distinct from the Java one, *H. Raciborskii*, Zimm., as the perithecia are just in the reverse position; if new to science, as it appears to be, it might receive the name of *Hypocrella coccophula* or *Lecanii*.

2.—On *Chionaspis vitis* on leaves of *Loranthus*, sp., Horton Plains, Sept., 1900.

The material was scanty, consisting in all of seven pale buff or whitish stromata. Only one of these possessed perithecia. The others were in the conidial (*Aschersonia*) condition. The somewhat flask-shaped perithecia measured 500 $\mu$  deep and 160 $\mu$  in the broadest part. The asci were apparently immature with thread-like spores forming in them.

3.—On *Lecanium*, sp., on lower surface of leaves of *Gelonium lanceolatum*, Pundalu-oya, Nov., 1898.

The conidial stages of this distinct and peculiar fungus are described under the Fungi imperfecti.

Sunk in the upper part of an old black stroma occurred flask-shaped perithecia with slender asci full of sporules quite small and cylindrical, resulting most likely from

the breaking up of thread-like ascospores (figs. 46, 47, 48).

This fungus with black hemispherical stromata is apparently a species of *Hypocrella*, but its conidial stage can hardly be included in *Aschersonia* on account of the colour and other peculiarities.

(?) Genus *Drussiella*, Pat.

The fungus, supposed to belong to this genus, has not been examined by the author. It is only referred to *Drussiella* on account of its external resemblance and habit to *D. tubiformis*, Pat., the only member of the genus, found on the haulm of a bamboo (*Arundinaria*) in tropical America.\*

The specimen in question has been found several times by Mr. Green on *Arundinaria* at Pundalu-oya, Ceylon. He considers it to always originate on a coccid. It commences beneath the leaf-scale of the bamboo and swells out into a large black tuber (stroma). The scale-insect, apparently associated with it, is *Aclerda distorta*.

*Pyrenomycetes-Perisporiales.*

Genus *Apisporium*, Kunze (*Capnodium*, Mont).

This genus consists of black fungi often found growing on "honey dew," deposited upon leaves by aphides and some kinds of scale-insects. It appears under several conidial forms, which are much commoner than the ascus stage.

An instance of *Capnodium* growing on the sugary excretion emitted by a coccid (*Monophlebus*) is recorded in a paper by Stebbing.† But it may also be parasitic on certain scale-insects as well. This, at any rate, is possible from a paper by Britton‡ on the natural enemies of the San José scale (*Aspidiotus perniciosus*). He mentions a fungus, probably a species of *Capnodium*, as causing a reduction in the number of scales on infested trees. If he is

\* "Die Pflanzenfamilien." Teil I., Abtheil. I., p. 367.

† Stebbing. Journ. Linn. Soc., XXIX., 1904, p. 154.

‡ Britton. U.S.A. Exp. Sta. Connecticut, Report Entom. pt. II., 1902.

correct in his identification of the fungus, it is an interesting fact, for the Diaspidinæ, to which the San José scale belongs, do not secrete "honey dew;" thus the fungus can hardly in this case be growing upon such excretion.

*Plectascineæ.*

Genus *Myriangium*, Mont. and Berk.

A black fungus referable to this genus has often been observed in Ceylon on the surface of leaves and stems associated with Coccidæ.

Zimmermann\* has come across a similar fungus at Buitenzorg in Java on leaves of *Coffea liberica* and *Elæis*, sp., and associated with the scale *Ichnaspis filiformis*. He names it *Myriangium Duriei*, Mont. and Berk.

The genus in "Die Pflanzenfamilien†" has a special tribe to itself, the Myriangiaceæ, which is attached to the Plectascineæ, one of the main divisions of the Ascomycetes. Three species are mentioned there. Others have been added since.‡

The fungus consists of a moderate amount of hard pseudo-parenchymatous black stroma situated on the surface of leaves or stems. From this the perithecia grow out as circular protuberances compressed together. It has no ostiole like the true Pyrenomycetes, but when ripe its hard wall breaks away scattering the spores. The asci are not borne on a special hymenium in the perithecium, but irregularly distributed through a ground tissue filling the receptacle. The inner part of the wall of the ascus is mucilaginous, and by the swelling of this it bursts and the spores are released. The ascospore is hyaline, multicellular, muriform with slight constriction in the middle.

The Ceylon form has perithecia measuring in height 300-375 and in breadth 420-675  $\mu$ , asci ovate to globular

\* Zimmermann, *loc. cit.*

† Teil I., Abth. I., p. 319.

‡ Hennings, Hediwigia, XLI., Beiblatt 2, 1902, p. 54. McAlpine, "Australian fungi, two new species of *Myriangium*," Linn. Soc. N.S.W. April 27, 1904.

$40 \times 30 \mu$  (fig. 26) and ascospore  $20-30 \times 8-11.5 \mu$  (fig. 27).

It agrees very closely with Zimmermann's description. His measurements are for the ascus  $35 \mu$  long and for the spore  $25 \times 10$ .

It has been chiefly studied on *Aspidiotus camelliae* on the stem of *Osbeckia* (fig. 25), and on *Chionaspis biclavis* on *Tabernæmontana*.

A curious point is that it has almost invariably been found associated with scales attacked by the *Nectria* already described, suggesting the possibility of the one fungus being in some degree dependent on the other. *Myriangium* being a black fungus and not unlike in external appearance and habit to *Meliola* and *Capnodium*, which follow "honey dew," it might be thought to be connected with such coccid excretion. This, however, cannot be the case here as it has only been found associated with scale-insects which do not excrete "honey dew." Notwithstanding I have always had a doubt of its parasitism. Zimmermann expresses a similar doubt. He says the fungus is not bound to the presence of the coccid and perhaps penetrates dead scales only. On account of its association with the *Nectria* it may follow this fungus as a scavenger feeding on the remains of the scales and possibly on the *Nectria* itself; thus it is probably only a saprophyte. Further observation together with inoculating experiments should explain its share in the destruction of the coccid.

A black conidial form similarly situated as the above has been found on two occasions in connection with *Mytilaspis citricola* on Citrus, and *M. lasianthi* on *Codiaeum*, both scales being at the same time attacked by *Nectria*. It possessed receptacles (pycnidia) holding pale brown oval conidia produced by a hymenial lining and measuring  $4 \times 3 \mu$ . Most likely this is the conidial stage of the *Myriangium*, but direct proof was not obtained. No conidial fructification is mentioned for the genus in "Die Pflanzenfamilien."

## (B) FUNGI-IMPERFECTI.

*Sphaeropsidales-Nectrioidaceæ.*Genus *Aschersonia*, Mont.

This genus\* was founded in 1848 by Montagne for certain conidial stages of fungi collected in the tropics on the surface of leaves. It is characterized by possessing brightly coloured hemispherical, turbinate, or pulvinate stromata, the surface of which is sprinkled over with darker coloured dots, the openings to the sunken conidial receptacles (pycnidia). The conidia are very small, fusiform, and hyaline, and are borne singly on short filiform hyphæ, which line the pycnidium and which have interspersed amongst them, as a rule, longer sterile ones, paraphyses.

In 1893, in Florida, Webber found on orange leaves badly infested with a scale-insect known as the mealy wing or white fly (*Aleurodes citri*), highly coloured pustules of a fungus. The insects and the pustules were mingled together on the surface of the leaves. Finding the fungus similarly associated on several subsequent occasions, he was led to regard it as most likely parasitic on the insect. A preliminary account of the fungus was published in 1894,† when it was provisionally referred to *Aschersonia tahitensis*, Mont. Since then the fungus has been examined by Patouillard and compared with the original specimens of *A. tahitensis*, with the result of making this fungus of the orange groves of Florida a distinct species, *A. aleyrodis*, Webber. It appears to differ, however, only slightly from *A. tahitensis*. A full account of the fungus is given in Webber's paper "On the Sooty Mold of the Orange and its Treatment."‡ In this treatise are mentioned four other kinds of *Aschersonia* parasitic on scale-insects, but a full description of them is reserved for a future occasion.

\* Hennings, "Die Gattung *Aschersonia*, Mont." Festschrift für P. Ascherson, 1904, p. 68.

† Webber, Journ. of Mycol., VII., p. 363.

‡ Webber, U. S. A. Depart. Agric., 1897, No. 13.

Thus Webber was the first to discover *Aschersonia* to be parasitic on insects. He considers his observations to strongly indicate the general entomogenous nature of the genus. Though its members have in the past been described as growing (presumably parasitic) on leaves, yet it is quite possible that a coccid might be the true host. The fungus in its mature state so completely envelopes the scale, that the remains of the latter can only be made out by examining sections with a microscope. Thus unless suspicion was aroused, systematists might easily be deceived and imagine that the fungus was growing directly on the leaf. The whole genus requires fresh study from this point of view.

Till 1900 the genus consisted of some twenty species. Recently Hennings\* has added five new ones from specimens received from Java. They are described as usually associated with different kinds of *Lecanium*, which they resemble in shape and colour. One of them, *Aschersonia sclerotoides*, P. Henn., is definitely mentioned as being situated upon a *Lecanium* on *Castilleja elastica*. It seems to me that here again the fungi have probably developed on the scale-insects rather than at the expense of the leaf-tissue.

Numerous forms of *Aschersonia* have been found in Ceylon on species of *Aleurodes* and *Lecanium*. In all cases their stromata were readily detached from the foliar surface, and no hyphæ have been seen penetrating the leaf.

The specimens to be described are separated into three groups. Each group may represent one species or perhaps more than one. The differences between forms are often so indefinite, that much more study of the whole genus is required before a useful separation into species can be attempted.

These conidial forms grouped under *Aschersonia* very likely belong to the genus *Hypocrella*. Direct evidence for this view has been given previously (see p. 29).

\* Hennings, *Hedwigia*, XLI., 1902, p. 140. For a recent enumeration of the species and an account of the genus, see Hennings, *estschrift für P. Ascherson*, 70 Geburtstages, 1904, p. 68.

*Ceylon Forms.**A.—Forms resembling Webber's Aschersonia aleyrodis.*

Seven different lots of material collected in Ceylon have been examined, as well as a specimen from Sumatra. These have been compared with some of Webber's own material, kindly sent by him to Mr. Green and passed on to me.

Without more examples and further investigation it is impossible to claim all these forms as identical with *A. aleyrodis*. Some seem to resemble *A. tahitensis* more closely. But no sharp line of demarcation between the several forms could be made.

The conidium (fig. 30) in all is very similar, measuring  $9-13 \times 1.5-2\mu$ ; it may be 3-guttulate. Paraphyses are uniformly present, but I have not been able to detect in them the peculiar darkened cells (segments) mentioned by Webber as being quite characteristic of *A. aleyrodis*.

The stromata as a rule have the flattened hemispherical shape. The pycnidial orifices are either arranged in a circle or else dotted irregularly over the surface.

The colour of the stroma varies from creamy white to bright orange-yellow, and that of the orifices may be brick-red, orange-red, or dull green. A membranous border, termed the hypothallus, surrounding the stroma and closely adherent to the leaf surface, may be present or absent. *A. aleyrodis* possesses one about a millimetre wide, while *A. tahitensis* does not.

1.—On a black *Aleurodes*, sp., on the lower surface of the leaf of *Andropogon muricatus* (cuscus grass) figs. 28 and 29.

Stroma creamy-yellow, pycnidial orifices red-brown, fairly numerous and scattered, hypothallus present.

Some stromata kept for a short time in a closed vessel showed columns of conidia rising from the pycnidial orifices in a similar manner as described by Webber.\*

This form closely resembles *A. aleyrodis*.

2.—On a black *Aleurodes*, sp., on the lower surface of the leaf of *Hedyotis verticillaris*.

\* Webber, *loc. cit.*, p. 22.

Stromata small, pinkish white; pycnidial orifices conspicuous, coral red, few in number and often arranged in horse-shoe fashion: only slight development of hypothallus. Similar to 1, except as regards hypothallus.

3.—On a black *Aleurodes*, sp., on the lower surface of the leaf of *Ochlandra*, sp. (a bamboo). figs. 31 and 32. A fine lot of material collected by Macmillan at Pussella, Feb., 1899.

Stroma creamy white, much flattened with irregular surface, large, as much as 4.5 mm. in diameter, 0.5–0.75 mm. in thickness, neighbouring ones often fused together owing to the scales being so numerous; pycnidial orifices yellow brown or greenish, inconspicuous, numerous, often crowded on the central raised part of the stroma: no definite hypothallus; pycnidium  $180\mu$  deep, very definite in shape being oval in longitudinal section with a very short neck.

This form differs from 1 and 2 in the paler and flatter stroma and in the smaller and more numerous pycnidial orifices. However some of little and perhaps younger stromata more nearly resemble 1 and 2.

4.—On a pale *Aleurodes*, sp., on the lower surface of the leaf of *Memecylon capitellatum* (figs. 33, 34, and 35).

Stroma bright yellow, fades with age: pycnidial orifices deep orange, conspicuous, often arranged in a circle or horse-shoe; a very marked hypothallus present as a rule. This *Aschersonia* in all essential features, except colour, resembles *A. aleyrodis*.

Interspersed with it on the same scale were plentiful flat brown circular pustules resembling Webber's sterile "brown mealy-wing fungus." It is described in a later section of this paper.

5.—On a pale *Aleurodes*, sp., on the lower surface of the leaf of *Flemingia strobilifera*.

Stroma buff-yellow, averaging 1 mm. in diameter; pycnidial orifices conspicuous, orange, few in number and often arranged horse-shoe fashion; hypothallus present, extending 0.5 to 1 mm. from stroma.

Resembles 4 very closely. A few of the stromata were old and shrunken without hypothallus, and brown or olive green in colour.

6.—On a pale *Aleurodes*, sp., on the lower surface of the leaf of *Diospyros Toposia*.

Very similar to 5, but the hypothallus not so wide, about 0.32 mm.

7.—On a pale *Aleurodes*, sp., on the lower surface of the leaf of *Filicium decipiens*.

Stroma olivaceous, without hypothallus; pycnidial orifices arranged more or less in a circle.

Most likely old stromata, similar to the old ones mentioned under 5.

The presence or absence of a hypothallus appears to me of doubtful taxonomic value. Stromata on the same leaf may or may not have it markedly developed. Atmospheric conditions perhaps have something to do with its development.

Of course such a character as to whether the fungus is epi- or hypo-phyllous is of no value, as naturally the position varies with that of the insect. Coccids usually frequent the lower surface of leaves, no doubt for protection.

B.—*Forms with rich brown unflattened stromata without paraphyses.*

This type has only once been found in Ceylon, but Mr. Green has passed on to me three apparently identical examples he has received from India.

The stromata are large, hemispherical, or even two-thirds of a sphere in shape. The surface is irregularly furrowed. The pycnidial orifices are inconspicuous and fairly numerous. There is no hypothallus. The conidia appear less fusiform, more lenticular than those of Group A., measuring 6-12  $\times$  4-5  $\mu$ , fig. 38.

They are all perhaps identical with one another and distinct from those of Group A. It is significant that they occur on *Lecanium* and not on *Aleurodes*.

1.—Ceylon example on *Lecanium psidii* on stems and midribs of *Myristica moschata* (figs. 36 and 37).

Stroma buff coloured; pycnidial orifices scattered; pycnidia regular in shape and rather shallow. A fine specimen.

*Indian examples.*

2.—On *Lecanium hemisphaericum* (var. *coffea*) on tea leaf and stem, Upper Assam.

Stroma fulvous or clay-coloured; pycnidial orifices of a darker shade and scattered.

3.—On *Lecanium*, sp., on tea stem, Kurseong.

Stroma orange to brick-red, basal part yellow; pycnidial orifices irregularly arranged.

4.—On *Lecanium*, sp., on tea leaf and stem, Darjeeling.

Stroma clay-coloured with lighter tinted base.

C.—*Form with large pycnidium, only 1-3 to a stroma.*

Quite a different type of *Aschersonia* to the preceding was found on a single occasion in the jungle, Horton Plains, Ceylon, by the author. Only a few stromata were obtained. The fungus was formed on a species of *Aleurodes* on the lower surface of the leaf of *Eugenia revoluta* (fig. 39).

The mature stroma possessed a hypothallus, surrounding a slightly raised yellow cushion from which projected upwards a short column. This bifurcated at the top into two short processes each ending in a large opening, the pycnidial orifice (fig. 40). One stroma had only a terminal orifice; and another had three. The pycnidium is deep and somewhat lobed at the base (fig. 41).

The orifices were plugged with yellow-brown or olive-green gelatinous masses of conidia. These latter, of the usual *Aschersonia* type, measured  $10 \times 2\mu$  (fig. 42).

*A Fungus with Aschersonia-like Stromata but black.*

A distinct fungus resembling *Aschersonia* in shape and habit, but black, was found in 1898 by Green in the jungle, Pundalu-oya, Ceylon, and handed to me for examination.

The dark pustules occurred on the lower surface of leaves of *Gelonium lanceolatum* and were not at all abundant—never more than two or three on a leaf and those bearing them were scarce. The evidence for their position on a scale was not conclusive.

Two or three months later while on a visit to Horton Plains, I found a few similar pustules on the upper surface of leaves of *Calophyllum Walkeri*. In this case there was no doubt of the fungus being on a scale-insect, as sufficient remains were there to allow Mr. Green to identify it as a species of *Lecanium*.

A third example, probably identical with the above, was sent to Mr. Green from Java. It was on a *Lecanium*, sp., on the leaf of *Jambosa aqua*.

#### *Description of the Fungus.*

The dark brown or black pustules (stromata) are hemispherical in shape with an even surface and with usually a swollen basal collar. The colour of the interior is orange, only the exterior is black. They measure from 1-2 mm. in height.

Some, apparently the younger ones, were covered (especially the upper part) with a gray bloom, easily rubbed off revealing the shiny black surface beneath. This bloom is composed of conidia. In fact nearly the whole surface of such a stroma is covered with a conidia-bearing hymenium, similar to what lines the pycnidia of *Aschersonia*. The conidia resemble those of this genus being fusiform, hyaline, and guttulate, and measuring  $8 \times 2\mu$  (fig. 45).

Some stromata possessing this bloom revealed, with the aid of a lens, minute pores arranged in a circle around the lower part; these are the openings of pycnidia, likewise lined with a hymenium bearing conidia similar in size and shape to the superficially borne ones. The pycnidium is somewhat lobed or branched (figs. 43 and 44).

In what was most likely a still older stroma, which had lost its bloom and looked shrunken, were flask-shaped

perithecia with asci. These occurred sunken in the upper part of the stroma. Reference has already been made to this example under *Hypocrella* (see p. 30).

Hence it is probable that all the above black pustules belong to a species of *Hypocrella*.

The conidial stroma though suggesting *Aschersonia* differs from all hitherto described species; if it is to be admitted, then the characters of the genus will require to be somewhat modified.

By searching the up-country jungles of Ceylon more of this fungus might be procured and thus permit its systematic position to be definitely settled.

*Hyphomycetes—Mucedinaceæ.*

Genus *Cephalosporium*, Corda.

As was pointed out in the introduction to this paper, Zimmermann named a fungus which he found attacking the green bug (*Lecanium viride*) on the coffee in Java, *Cephalosporium Lecanii*.

The short account\* he wrote about it was intended more for the benefit of the Java planters than as a botanical treatise. Beyond this pamphlet I have come across no further allusion to such a type of fungus in connection with scale-insects.

In Ceylon a fungus similar to this Java one has repeatedly been observed by Mr. Green and myself on species of *Lecanium*. In fact he has been aware of it in the Island for some years on the green-bug. To particularize, four separate lots of material have been collected on *L. viride*, three lots on *L. hemisphericum*, and two on *L. nigrum*. For details see Table at the end.

The fungus shows itself to the naked eye as a white or pale yellow powdery bloom around, and to some extent over the scales (figs. 49 and 50). The powdery or mealy appearance is due to innumerable conidial heads covering the

\* Zimmermann, "Over eene Schimmel epidemie der groene Luizen." 1898, *Biutenzorg*, Java.

hyphæ. The external part of the fungus develops as follows:—Hyphæ radiate out on all sides from below the scale for a millimetre or more over the leaf surface. Each hypha produces at frequent intervals short lateral branches, the conidiophores,  $16-20\mu$  in length. Each conidiophore bears on its apex a spherical head of conidia, enveloped in mucilage (fig. 53). This head with a diameter of  $4\mu$  appears when dry as a glistening globule, the individual conidia not being distinguishable. On treatment with water the mucilaginous matter dissolves and the conidia are dispersed; sometimes the last one produced remains attached to the tip of the hypha. In order to examine the conidia *in situ*, the fungus should be mounted in dilute acetic acid, which prevents the mucilage from dissolving and renders the conidia visible (fig. 54). Five to seven are usually present in one head. They are really abstricted from the conidiophore in succession, but instead of remaining in a chain become aggregated together into a spherical mass by the mucilage which is secreted. Some infected scales kept in a damp atmosphere showed conidiophores bearing conidia in short curved chains, owing perhaps to mucilage not being able to mass them together.

The colourless conidia are minute measuring  $3.5-4 \times 1.4\mu$ , figures almost identical with those given by Zimmermann for the Java form. They are shortly cylindrical or nearly oval or slightly sausage-shaped.

The conidiophores may be so numerous that here and there the mucilaginous heads, which touch one another, fuse to form larger masses of conidia.

The lateral short branches of the main hyphæ, which here are termed conidiophores, may even branch themselves, so as to produce two to four heads of conidia (fig. 52).

If a scale from affected material, but with no external fungus visible, be removed from a leaf and placed on a microscopic slide in a damp chamber, the development of the conidial part outside the insect can be readily followed. After one day the radiating hyphæ proceeding from the

margin of the scale were just visible ; after two days the first conidiophores appeared, and after four to five days the whole insect was surrounded by a fringe of hyphæ bearing numerous conidial heads (fig. 51).

An example of *Cephalosporium* parasitic on *Lecanium hemisphaericum* var. *coffea* on the stem of *Jussiaea suffruticosa* possessed a few perithecia. These were resting on the peripheral part of the fungus, and were globular in shape and pale yellow in colour. The long asci within unfortunately showed no definite spore formation, and so were most likely immature. However, their presence points to the probability of this *Cephalosporium* being a conidial stage of some genus of the Hypocreales, to which group nearly all the other Ascomycetous scale-fungi described belong.

Before leaving this genus a remark is needed upon its systematic position in the Fungi imperfecti. According to the synopsis given in "Die Pflanzenfamilien"\* *Cephalosporium* is placed in a small group of genera characterized by the conidia *not* being enveloped in mucilage, whereas the neighbouring genus *Hyalopus* has its conidia so held together. The Ceylon forms and the Java one, according to Zimmermann, possess mucilage, so on this classification they should both be referred rather to *Hyalopus*.

#### Genus *Hyalopus*, Corda.

A new scale fungus has quite recently been described by Dop† who refers it to the genus *Hyalopus*.

About 1902 the cocoanut palms of Martinique were severely attacked by a scale-pest, a species of *Aspidiotus* very closely allied to the San José Scale (*A. perniciosus*). In fact the pest assumed such alarming proportions as to threaten the cultivation of these palms. Suddenly the insect received a check, and in a comparatively short time disappeared. Dop has shown this to be due to the rapid spread of a fungus

\* Teil I., Abtheil. I., pp. 417-418.

† Dop, Bull. Scient. France et Belgique. XXXIX., 1905, p. 135.

disease. He names the species *Hyalopus Yronis*, in honour of M. Saint-Yves of Martinique. He says it differs from *Acrostalagmus coccidicola* referred to below, in slight details, chiefly in having simple and not branched or whorled conidiophores. It forms little gray patches over and around the scales. The fertile hyphæ (conidiophores) are upright, and are each terminated by a mucilaginous sphere containing several conidia measuring  $4 \times 1-1.5\mu$ . These readily bud like yeast in water.

The investigator has tried various culture and inoculation experiments. In a 5 per cent. sugar jelly the fungus increases wholly in the yeast fashion, hyphæ only appearing as the nutritive material becomes exhausted. In broth made of scale-insects the conidia form a mycelium. Hence the fungus may either assume a mycelial or a yeast form, according to the medium, in which it is grown. In the body of the coccid it appears to increase yeast-like, but externally it forms a mycelium bearing the above mentioned conidiophores.

His inoculations have only been partially successful. He has tried them on *Aspidiotus Nerii*, and finds that success only attends inoculations with the yeast form. He has not been able to obtain by artificial infection a mycelium bearing conidia.

This fungus is evidently near akin to the Ceylon and Java *Cephalosporium*, though hardly identical. Its great capacity of budding like yeast is a difference. It is a point also of some significance to note that this fungus occurs on *Aspidiotus*, whereas *Cephalosporium* has so far been only found on *Lecanium*.

#### Genus *Acrostalagmus*, Corda.

This genus differs from *Cephalosporium* in having upright conidiophores, branched in a verticillate manner. Guégnen\* describes in his recent work "On Fungi Parasitic on Man and Animals," a new species which he found growing on the scales of a coccid on a shrub in a green-house

\* Guégnen, *loc. cit.*, p. 253.

in the Paris Exhibition of 1900. He names it *A. coccidicola*. The mycelium formed around the body of the insect is of a deep yellow colour.

The fungus is easily cultivated upon various artificial media. The mucilaginous heads usually contain 10-12 conidia, occasionally as many as 16. The conidium is cylindrical  $4-5 \times 1\mu$ .

This fungus is evidently distinct from the Java and Ceylon *Cephalosporium* just described, though perhaps somewhat allied. The species of scale-insect, upon which it was found, is not mentioned in the account.

#### Genus *Sporotrichum*, Link.

Guégnen\* in his account of the species of this genus found growing on insects, mentions one, *S. Lecanii*, discovered by Peck in North America on a *Lecanium*. This is the only instance of this habit for the genus I have been able to find. No Ceylon specimen on a coccid has yet been found.

Another species, *S. globuliferum*, Speg., is a well-known parasite of the Cinch-bug (*Blyssus leucopterus*). Inoculating experiments with it have been conducted in the United States of America.†

The genus *Sporotrichum* is closely related to *Botrytis*.

#### Genus *Verticillium*, Nees.

An example of this genus on a coccid was found for the first time some years ago in North Italy, and named *V. heterocladium*, by Penzig.‡ It was growing on *Lecanium hesperidum* on orange leaves, covering the scales with a white mould. This fungus according to Guégnen's account§ appears to be widely spread; it has been obtained both in Africa and the Antilles.

\* Guégnen, *loc. cit.*, p. 251.

† Forbes, Illinois Agric. Exp. Station, No. 38, 1895; Garman, Amer. Monthly Micro. Journ. XXIII.

‡ Saccardo, S. F., vol. IV., 1886, p. 151.

§ Guégnen, *loc. cit.*, p. 252.

A mould referable to this genus was found by the author in the Royal Botanic Gardens, Peradeniya, Ceylon, on the scale, *Asterolecanium miliaris*, which was infesting the leaves of a bamboo bush. A curious point about the position of the fungus was its restriction to those scales fixed to the lower side of the leaves, while those on the upper surface were attacked by a species of *Nectria* already described (see p. 24).

The *Verticillium* covered the scale with a gray mycelium, which extended as well some distance around over the leaf surface. The scale together with the fungus could easily be detached with a needle from the leaf and mounted on a slide for examination. Through the microscope numerous conidiophores could be seen standing erect from the mycelium. Each is composed of a stalk bearing at the top a single whorl of 5-9 short pointed branches, sterigmata, bearing solitary conidia (fig. 55). The stalk measured  $38-44 \times 3\mu$ , the sterigma  $8-11\mu$  in length, and the conidium  $4 \times 1.4\mu$ . The latter is slightly curved, in fact sausage-shaped.

Thus the Ceylon specimen has an unbranched conidiophore with one whorl of sterigmata, whereas the genus is usually characterized by possessing several superposed or alternate whorls of sterigmata. *V. heterocladium*, already alluded to, has a compound conidiophore with verticillate branches; so the Ceylon specimen is quite different from it.

*Hyphomycetes-Dematiaceae.*

(?) Genus *Peziotrichum*, Sacc.

A totally distinct and new scale fungus was found by Mr. Green on *Chionaspis aspidistrae* on the leaf of a small pot palm at Peradeniya, October, 1899. More of this fungus has since been obtained by him on *Aonidia*, sp., on *Memecylon* leaf, Elephant Pass, Ceylon. It is a conidial form and was briefly referred to in the paper\* read before the British

\* Parkin, *loc. cit.*

Association in 1900, as belonging to the Dematiaceæ, probably near the genus *Campsotrichum*. On closer examination it agrees better with the neighbouring genus *Peziotrichum* founded by Saccardo in 1893,\* to receive a fungus collected in Australia on twigs and thorns of *Bursaria spinosa*. It differs in having spherical instead of cylindrical conidia, and so agrees with *Botryotrichum* in this respect.

The Ceylon fungus appears to the naked eye as a minute tuft of brown or black bristles standing up around the scale, subtended by a small amount of brown mould covering and surrounding the scale (figs. 56 and 57). A microscopic examination reveals the following structures. From below the scale proceed horizontal hyphæ ramifying a little way over the leaf surface. These produce at frequent intervals very short side branches, each bearing a large apical spherical conidium (figs. 60 and 61). The upright sterile bristles are attached to the rest of the fungus close to the margin of the scale. In fact the external visible part of the fungus consists: (1) of a creeping mat of septate hyphæ covering and surrounding the scale, and bearing on short lateral processes single conidia; and (2) of sterile stouter septate hyphæ cohering together to some extent in bundles and standing erect around the periphery of the scale. The whole fungus, with the exception of the hyaline tips of the bristles, is brown throughout, including the conidia. The spherical conidium,  $16\mu$  in diameter, has a yellow-brown wall and contents which stain deeply with iodine, suggesting the presence of glycogen.

The main conidial hyphæ have a thickness of  $4-5\mu$ , and the bristle ones of  $8-10\mu$  near the base. These latter taper somewhat towards the apex, are regularly septated and have a colourless slightly swollen apical segment (figs. 58 and 59): total length  $0.8-1$  mm. They cling together as a rule in bundles of 12 or so, the lower parts are often separate, but the upper parts are closely coherent. Special sterile hyphæ

\* Saccardo, Hedwigia. 1893. p. 58, and Syll. Fung. XI. 1895, p. 614.

(bristles) are common to several genera of this group (Amerosporæ) of the Dematiaceæ.

This Ceylon fungus differs in two small particulars from Saccardo's genus *Peziotrichum*. The conidia in colour are brown and not hyaline: in shape are spherical rather than cylindrical or rod-like. In fact, owing to its spherical conidia it approaches the next genus *Botryotrichum*.

As to the ascus-form of this fungus, no clue has yet been obtained.

### *HYPHOMYCETES-TUBERCULARIACEÆ.*

Genus *Fusarium*, Sink.

(See *Nectria*, pp. 21 and 25)

Genus *Microcera*, Desm.

This conidial genus as already pointed out (p. 12) was established by Desmazières in 1848 for a red fungus, *M. coccophila*, he found attacking scale-insects on tree-stems in France. Tulasne, in 1865, described the ascus-stage of this fungus, and named it *Sphaerostilbe coccophila* (see p. 27). The fungus has been shown in the past to be widely spread in Europe and N. America on coccids belonging to the Diaspidinæ.

Forms referable to *Microcera* have been found on several occasions in Ceylon in the year 1898 and subsequently. Specimens have also been received by the author through Mr. Green from West Africa, Mauritius, and the West Indies. Species considered distinct have been described for Australia and Tasmania. Thus *Microcera* is probably widely distributed on scale-insects throughout tropical and temperate regions.

In most cases only the conidial fructification (*Microcera*) has been seen. *Perithecia* (*Sphaerostilbe*) appear to be commonly developed in the United States of America.\* In the Ceylon examples and in others examined by the author they have never been found. Thus the ascus-stage

\* Rolfs, Gossard, Forbes, *loc. cit.*

does not appear so readily as in the case of *Nectria coccidophthora*.

The forms of *Microcera* so far found on scale-insects have not all been referred to the original species, *M. coccophila*. Saccardo\* gives the characters of six species, two of which, *M. coccophila* and *M. rectispora*, are described as situated on coccids. *M. rectispora* was collected in Queensland on the orange, and named so by Cook and Massee.

Recently McAlpine† has diagnosed two new species, *M. tasmaniensis* and *M. mytilaspis*, from examples discovered in Tasmania and Victoria respectively. The former was found by Lea in 1901 on *Aspidiotus*, sp., on Eucalyptus bark; it differs from *M. coccophila* in colour, and in its conidia being only 3-septate. The latter was on *Mytilaspis*, sp., on *Hymenanthera dentata*; it is bigger and has multiseptate conidia.

*Ceylon Specimens of Microcera.*

The fungus first appears from below the scale at several points as small red protuberances. These enlarge and join to form a thick coral red stroma around, and to some extent over the scale. As a rule the stroma does not cover the whole exterior surface of the scale, the central part being left bare. The conidial fructifications (sporodochia) arise from slight depressions in the peripheral part of the stroma; they often radiate outwards in star-fashion. Each in its young state is enveloped in a loose sheath of whitish parallel fibres (hyphæ). On maturity the fibres of the sheath break away from one another at the top, and the bright red apex of the sporodochium shows itself. The broken sheath persists, partially covering the conical or cushion-shaped sporodochium. The individual hyphæ of the sheath have a thickness of  $4\mu$ , and are joined to one another here and there by very short lateral ladder-like connections, as in the closely adherent sheath of *Fusarium*, already described under *Nectria*.

\* Saccardo, S.F., vol. X., p. 731.

† McAlpine, Journ. Agric. Victoria; XI., part 7. 1904.

The conidia are of the *Fusarium* type (fig. 66). The number of their septa were observed to vary from 3 to 9. On the whole they are somewhat more curved than the conidia of *Nectria coccidophthora*. The hyphae bearing them are filiform and only branch at the base.

The Ceylon forms so far collected may be divided into three types; whether of specific value, it is difficult to say.

(a) On *Aspidiotus aurantii* and *Mytilaspis citricola* (fig. 62).

Stroma not conspicuously developed; sporodochia arranged in stellate fashion around the scale, as many as eight, cushion-shaped or conical, projecting outwards horizontally or slightly inclined upwards; its sheath may extend for  $600\mu$ , while the conidial part only projects  $370\mu$ , breadth varies from  $337-525\mu$  (fig. 63). Conidia, average size  $103.8 \times 4.6\mu$  with several septa.

(b) On *Aonidia bullata* and *A. crenulata* (fig. 64).

Stroma well developed, broad border  $133-160\mu$  wide; sporodochium only one (or at most two) to a scale, springing from the posterior end of the insect as a horizontal or obliquely inclined conical structure with its bright pink tip usually just visible amid the jagged fringe of the sheath, measuring  $150-300 \times 180\mu$  (fig. 65). Conidium  $80-88 \times 5-6.5\mu$ .

The position of the sporodochium is probably accounted for by the structure of the insect. In the genus *Aonidia* the scale is closed below, so the anal and genital apertures would afford the easiest exit for the fungus.

(c) On *Aspidiotus camelliae* (?) on the bark of a jungle tree.

Stroma conspicuous; sporodochia columnar or somewhat club-shaped, projecting vertically upwards around the scale, measuring  $600 \times 180\mu$ . The sheath, white or buff in colour; conidia, usual curved septate type  $80 \times 8\mu$ .

On one piece of bark around some of the scales pink perithecia of the *Nectria* or *Sphaerostilbe* type were situated,

probably the ascus-stage of this *Microcera*. However the proof of the two fungi being in connection was not clearly established by this material.

*Forms of Microcera from other Countries examined by  
the Author.*

1. On *Fiorinia fioriniæ*, lower surface of leaves of *Camellia*, Mauritius.

2. On *Aspidiotus articulatus*, Coffee leaf, West Coast, Africa.

3. On *Ischnaspis filiformis* and *Aspidiotus articulatus*, Coffee plant, Grenada, West Indies.

The above three appear identical with one another and also with the Ceylon type (*a*), which may be considered to be typical *M. coccophila*.

The septa of their conidia varied from 4-7. The conidium itself measured  $70-99 \times 3.8\mu$ . The sporodochia  $500 \times 350\mu$ .

Guégnen remarks in a note\* at the end of the section devoted to *Fusarium*, that *Microcera* in his opinion should be united to *Fusarium*, as the diagnosis originally given for it by Desmazières in 1848 is not distinctive enough. On referring to Desmazières' paper† I see that he lays stress on the sheath (velum) as a prominent feature. This structure has not been specially commented upon by later systematists. In "Die Pflanzenfamilien"‡ the difference between the two genera is vague. *Microcera* is said to possess conical or cushion-shaped sporodochia, while *Fusarium* has cushion or irregular shaped ones. Masee,§ in the British Fungus Flora, says *Microcera* is closely allied to *Fusarium*, but is distinguished by its small horn-like sporodochium. Both these authorities ignore the characters of the sheath. It is the presence of this white loose sheath,

\* Guégnen, *loc. cit.*, p. 263.

† Desmazières, *loc. cit.*

‡ Teil I, Abtheil I., 1900. p. 508.

§ Masee, *loc. cit.*, vol. III., p. 486.

which at first completely envelopes the conidial head and then partially breaks away, that distinguishes at a glance *Microcera* from the conidial stage (*Fusarium*) of the scale *Nectrie* already described. The sporodochium of these latter has been shown to be surrounded by a sheath of sterile fibres, which, however, cling persistently to the mass of parallel conidiophores within, and cannot be readily detached as a separate covering. Such a sheath is only evident on microscopical examination, whereas that of *Microcera* is clearly visible to the unaided eye. Provisionally I should be inclined to keep the two genera apart on account of this difference in the external covering of the sporodochium; *Microcera*, for example, to be characterized by having its sporodochium surrounded by a loose separate conspicuous sheath, and *Fusarium* by possessing a closely adherent inconspicuous one.

*Brown sterile Fungus associated with Aschersonia.*

Webber in his account of *Aschersonia aleprodis* refers to another kind of fungus growth\* on the mealy wing (*Aleurodes citri*). Since it never has been seen to produce any kind of fructification, he names it for convenience in his paper the "brown mealy wing fungus." He says it attacks the insect in any stage of development, and is more effective in destroying it than the *Aschersonia*; to quote a sentence, "In the grove where the fungus was first discovered, its spread was so rapid during the past summer that the mealy wing was almost eradicated." It forms hard smooth flat circular brown pustules, 0.5-2 mm. in diameter, over the insects. From such stromata a silvery white mycelium spreads in all directions over the leaf surface, even as far as 13 mm. By this means other scales on the same leaf are readily infected.

Pustules resembling these have been found on three occasions in Ceylon on species of *Aleurodes*.

\* Webber, *loc. cit.*, pp. 27-30.

1. On leaves of *Memecylon capitellatum* (fig. 33b), the same material as possessed the *Aschersonia* (p. 37).

The two fungi were irregularly distributed on the scales on the lower surface of the leaves throughout the bush. Some leaves possessed both kinds of stromata, while others might only have one sort.

2. On the lower surface of leaves of *Jasminum Sambac*.

In this case no *Aschersonia*, only brown pustules were present on the material received. The pustules are similar to the ones described by Webber, being rich brown in colour with a white membranous border from which hyphæ radiate out to some extent over the leaf surface.

3. On the lower surface of the leaf of *Calophyllum Walkeri*.

The brown pustules were not proved to be on scale-insects, but the supposition is likely.

Intermingled with the brightly coloured *Aschersonia* stromata on the leaf of *Flemingia strobilifera* (p. 37) were other brown ones. Many of these latter were evidently old or arrested *Aschersonia* stromata, as sections of them revealed closed pycnidia. Others again were flatter, more nearly resembling Webber's brown fungus, thus suggesting the possibility of all these sterile pustules being really connected with *Aschersonia*. The two fungi often appear in association on the same scale and even on the same leaf. Webber mentions that *A. aleyrodis* was present on those orange bushes containing also the "brown mealy wing fungus." In the Ceylon specimen on *Memecylon* the two were intimately associated. Atmospheric conditions such as dryness may so influence the development of the *Aschersonia* as to induce it to assume a sterile resting form. This, when conditions are again favourable, might send out infecting hyphæ over the leaf surface. Webber's account of how this brown fungus develops and spreads hardly favours such a view. However, its close association with *Aschersonia* is a point to

be kept in mind. By cultures perhaps this sterile form might be induced to form some fructification, and so a clue to its nature and relationship might be obtained.

### III.—GENERAL REMARKS.

*Distribution.*—Fungi parasitic, or at least subsisting on scale-insects, appear to be widely spread. They seem especially common in the tropics. As this paper shows, in the course of a few years many forms have been brought to light in Ceylon. Java has already produced several kinds. Specimens have also been received from various parts of Africa. Their occurrence has been noted in the West Indies. Maxwell-Lefroy,\* in his treatise on the Scale-Insects of the West Indies, says that fungus diseases are occasionally responsible for a great mortality among coccids. He refers to several noticed by him, which have as yet received no investigation.

In temperate regions they also occur, but not so abundantly. Several forms have been found and used for infection experiments in the United States of America. Their presence in Australia has also been recognized, as well as in New Zealand. Maskell,† in his account of New Zealand scale-insects, writes that "the too rapid increase of coccids is checked by fungoid growths which permeate the whole body of the insect and soon kill it." The genera he noticed to be attacked are *Ctenochiton*, *Locanium*, and probably *Eriocheton*. From his figures and short description the fungi suggest examples of *Aschersonia*. It is interesting to note that the specimens were observed on the natural vegetation of the forests.

In Europe the only scale-fungus which has been shown to be common is *Microcera*. In fact, for the British Isles they have hardly been recorded. Newstead, in his work on "The Coccidæ of the British Isles,"‡ in a short section devoted

\* Maxwell-Lefroy, West Indian Bulletin, vol. III., 1902, p. 314.

† Maskell, An account of New Zealand Scale-Insects, 1887, p. 22.

‡ Newstead, vol. I., 1901, p. 42.

to micro-fungi says, "In this country micro-fungi are only occasionally destructive to coccids, and so far as my experience goes only infest those species found on plants under glass." Again, "I have not met with a single instance of an outdoor coccid in this country being attacked by a fungoid disease. But future research may prove they are not immune from such attacks."

As a rule these fungi cause epidemic diseases amongst the scale-insects they attack, few scales on a plant or group of plants escaping. They appear spasmodically when the conditions are favourable and rapidly spread over the coccids infesting any particular plant or crop. In Java and Ceylon the green-bug (*Lecanium viride*) has been noticed to be affected in epidemic fashion by *Cephalosporium* over large tracts of coffee. In Florida *Aschersonia aleyrodis* has been observed by Webber to spread rapidly over the mealy wing (*Aleurodes citri*) on the orange. Microcera can also cause epidemics amongst the San José Scale (*Aspidiotus perniciosus*). A remarkable example quite recently brought to notice occurred in the island of Martinique. The cocoanut palms were suffering severely from an attack of a coccid, closely allied to the S. José Scale. A fungous disease suddenly appeared and spread with such rapidity amongst the scales as practically to save these trees from probable destruction.

Considering how few scales escape, and how difficult it is sometimes to find a single unaffected insect on a leaf possessing the fungus, it is quite possible that many fungi described by systematists in the past, as growing on the surfaces of leaves and stems, might have had scale-insects as their true hosts. For example, it is probable that the genus *Aschersonia* at first considered a leaf-fungus is really in the main or wholly entomogenous. In the recognized coccidophagous forms the scale is so enveloped by the stroma of the fungus, that its remains can only be seen with the aid of sections and a microscope. As already pointed out *Aschersonia* is probably the conidial stage of *Hypocrella*;

consequently this genus also may be largely or wholly entomogenous.

Again, the entomogenous nature of some of these micro-fungi can readily be overlooked owing to certain scale-insects fixing themselves below the outer bark of stems and thus becoming invisible. A fungus growing on them consequently looks as if it was coming straight from the tissues of the plant. This is the case with *Chionaspis biclavis*. The coccid conceals itself beneath the dead external layers of the cortex, incorporating particles of the bark into its scale. The specimen of *Nectria* on this insect found in Ceylon exemplifies this point.

### *Systematic Position.*

All the different forms of fungi so far discovered on scale-insects may be ranked as Ascomycetes, though the ascus-stage of many grouped under the Fungi-imperfecti is as yet unknown; but by analogy it is legitimate to consider them conidial fructifications of various Ascomycetes.

It is remarkable that no member of the simpler Phycomyces has so far been discovered parasitic on coccids, considering that one of its divisions, the Entomophthorineæ, is almost wholly entomogenous, containing the well-known genus *Empusa*, so destructive to house-flies, plant-lice, &c.

The Ascomycetes already found on coccids belong almost entirely to the Hypocreales, a family of Pyrenomycetes. This is an interesting fact, for the Hypocreales contain the familiar and largely entomogenous genus *Cordyceps*, chiefly parasitic on caterpillars. Representatives of eight or nine genera of the Hypocreales have been found on scale-insects. In addition to these a species of *Melanospora* is known to be entomogenous. It would not then be surprising to find the habit still more widely spread amongst this group.

Of the other two Ascomycetous genera mentioned in the systematic part of this paper, *Myriangium* is doubtfully

parasitic and *Apiosporium* (*Capnodium*) is little known at present.

The majority of the Fungi-imperfecti found on scale-insects are in all probability conidial stages of the *Hypo-creales*.

It is to be noted that certain of these fungi appear to be restricted to definite genera or tribes of coccids.

*Nectria* (with the exception of the form on *Asterolecanium*) and *Microcera* (*Sphærostilbe*?) are confined to the *Diaspidineæ*. The *Nectria* has already been met with on species of four genera and *Microcera* on those of five belonging to this subfamily.

Specimens of *Aschersonia* resembling Webber's *A. aleyrodis* have been found in nearly all cases parasitic on *Aleurodes*, spp. Another form appears restricted to species to *Lecanium*.

*Cephalosporium* has as yet only been examined on species of *Lecanium*, though Mr. Green has a recollection of observing such a fungus some years ago on *Asterolecanium*, which in spite of its name belongs to quite a different family.

To sum up, fungi have been found up to the present time on about ten distinct genera and on thirty species at least of *Coccidæ* and *Aleurodidaæ*.

Judging from the epidemic character many of these fungi assume, there is little doubt that they are real parasites and cause the death of the various scale-insects upon which they have been found growing. In those instances where successful inoculating experiments have been carried out, any doubt is removed. Although we feel justified in recognizing the majority of forms described as parasites, yet their parasitism is not perhaps of a very specialized kind. As Webber points out for *Aschersonia aleyrodis*, they may be obligate parasites in the early stage of development, and then continue their growth for some time after the death of the insect, absorbing almost the entire body, thus becoming facultative saprophytes.

*Cultural and Infection Experiments.*

Such of the fungi as have been used for experiment are easily cultivated on artificial media, showing that they have not become so specialized as to need their own particular insect as food. The spores of several kinds tried by the author germinated readily in water.

Rolfs has succeeded in cultivating *Sphaerostilbe* (*Microcera*) on bread, agar, gelatin, &c. He finds slightly acid bread a very useful material.

Zimmermann has shown that the Java *Cephalosporium* grows readily on agar substratum, provided with various nutrients. By this means crops of conidia can be obtained.

Gnégnen found he could cultivate *Acrostalagmus* on a variety of substances.

The ease whereby these fungi can apparently be artificially cultivated is a point in their favour for their possible use as checks to scale-insects.

Infection experiments have not so far been extensively tried, but such as have been attempted have often been failures, except those with *Microcera* in the United States.

As regards the *Aschersonia aleyrodis* of Florida, Webber reports that orange trees infested with mealy wing, but possessing no fungus upon them, have been sprayed with a mixture of conidia and water on several occasions with no result. Another method attempted was to hang orange branches containing *Aschersonia* pustules over trees possessing healthy mealy wing larvæ. In this way it was thought that the conidia would be washed down by the rain and infect the insects. Only in one out of several trials did the *Aschersonia* make its appearance. Hence he goes on to say that the most satisfactory way of introducing the *Aschersonia* into orange groves is to transplant into them small trees containing the fungus, allowing the foliage to intermingle freely. Several experiments of this kind have given satisfactory results with the *Aschersonia* as well as with the "brown mealy wing fungus."

Zimmermann records in a footnote to his pamphlet (*loc. cit.*) a case of successful infection of the green-bug (*Lecanium viride*) on the Java coffee by an artificial culture of *Cephalosporium*. The conidia were apparently applied to the bugs with a damp brush.

Green has tried inoculating *Lecanium psidii* with an artificial culture of the *Aschersonia* found growing on it without success. In a letter he writes, "All endeavours to communicate the disease by these means to healthy individuals completely failed. I tried it under different conditions, but with equally negative results."

Attempts made by the author at Peradeniya to infect scales of *Lecanium viride* with *Cephalosporium* were also failures. The conidia were painted over the scales with a damp brush, but no development of the fungus upon them was shown after the lapse of several days.

Guégnen has tried inoculating coccids with the *Acrostalagmus* discovered by him without success, but it is not clear from his account as to whether the insect upon which he experimented was the same as the one upon which he found the fungus growing naturally.

The conditions for successful inoculation are, therefore, somewhat obscure. Possibly the fungus-spore has to exist previously on the area of the leaf upon which the coccid fixes itself. It then germinates beneath the young scale, penetrating the soft parts. Spraying with decoctions may not succeed owing to the germinating spores merely alighting on the hard external shell of the coccid where, unable to penetrate, they dry up, and die, before they can produce sufficient hyphæ to effect an entrance below the scale. It has been pointed out that many of these spores germinate readily in water, and of course once sprouted easily die if the conditions for growth are unfavourable.

Careful investigation is required to ascertain how the germinating tube of the spore first gains access to the interior of the scale-insect, as well as to follow out the early development of the fungus in the host. Perhaps these fungi chiefly

attack the immature coccid larvæ, which at first are sheltered by the old mother scale, and then escaping lead a brief free existence before fixing themselves permanently to the plant. The insect may possibly pick up the fungus spore during its short active state.

### *Natural Means of Dispersal.*

Fungus spores are most commonly carried by the wind. For many of these coccidophagous fungi, this can hardly be the case. The conidia of *Nectria* (*Fusarium*), *Microcera*, *Cephalosporium*, and others, are held together by soluble mucilage, so in these cases rain and dew must act as distributors to some extent, though owing to scale-insects being usually attached to the lower side of leaves, the fungi upon them are not so readily wetted by rain, nor can their spores be so easily carried by it from one leaf to another.

Considering the rapid spread some of these fungi have been observed to make in orange groves and coffee plantations affected by scale pests, they must have some quick means of distributing their conidia. Webber, in dwelling upon this point, suggests ants as a means, especially since such insects are in the habit of visiting those coccids which excrete honey dew. Ants are exceedingly common in the tropics. He also suggests that they may be attracted too by the brightly coloured conidial masses of the *Aschersonia*. Of course this idea about ants could not well apply to coccids of the sub-family *Diaspidineæ* which do not excrete honey dew, and are therefore not visited by them.

In *Ascomycetes*, as a rule, the conidia serve the purpose of increasing the fungus in the area in which it has established itself; they are produced in great abundance, germinate quickly, and soon lose their vitality. The ascospores serve rather to start new colonies elsewhere; they only appear towards the end of the life of the fungus and retain their vitality for a long time. This may also be the case with the coccidophagous fungi, such as *Nectria* which

produces both kinds of fructifications. Hence the ascus stage is only to be expected in old material. In fact sometimes they may not be formed till the leaf has fallen.

### *Economic Value.*

As regards the economic importance of these fungi, they have only as yet been used with success in the United States. Webber considers *Aschersonia* and its associate the sterile brown fungus as most useful in checking and even eradicating the mealy-wing (*Aleurodes citri*), and so indirectly the sooty mould of the orange. Rolfs, Forbes, and Gossard have shown that *Microcera coccophila* can be employed as a permanent check to the harmful San José Scale. In fact under certain circumstances the fungus is considered to be quite capable of controlling this pest without the aid of artificial insecticides. The conditions favourable for its growth are, as one might expect, moisture and warmth. For these reasons Ceylon should be especially suitable for experimental work with these natural enemies of scale-insects.

Perhaps a little caution should be exercised before making use too freely of these fungi, till their peculiarities are thoroughly known. Some species of *Nectria* are noted "wound" parasites on trees. The cacao-canker of Ceylon, recently studied by Carruthers, is due to a *Nectria*. It would be interesting to experiment and see if the scale *Nectria* of Ceylon could act as a "wound" parasite. Will its conidia germinate and cause disease when placed in a wounded region of a plant, especially such a one as is frequented by the particular coccid? It is hardly likely, but perhaps advisable to try, before recommending such a fungus as a remedy for certain scale pests.

Considering the importance "biological" species have assumed in the case of Rusts (*Uredineæ*) and Mildews (*Erysipheæ*), it would be instructive to see if anything of the kind exists amongst these scale-fungi. For example, will

the *Cephalosporium* of *Lecanium viride* readily infect *Lecanium nigrum*, and *vice versâ*; or are these *Cephalosporia* physiologically distinct, though morphologically identical? Some such distinction has been shown for species of *Empusa* on flies.\*

#### IV.—SUMMARY.

1. Fungi growing upon scale-insects appear to be widely spread. They are especially common in the tropics, but less so in temperate regions. A great number have been found in Ceylon.

2. They often attack the insects in epidemic fashion. This has been chiefly observed in the case of *Aschersonia*, *Cephalosporium*, and *Microcera*.

3. There seems no doubt of the parasitism of most of the forms, or at least that they are the direct cause of the insect's death. The parasitism is perhaps not of a very specialized kind. Some have been observed in America to check and even to eradicate such destructive pests as the San José Scale (*Aspidiotus perniciosus*) and the mealy wing (*Aleurodes citri*.)

4. The commonest genera are *Nectria*, *Aschersonia*, *Cephalosporium*, and *Microcera*; at least, as far as Ceylon is concerned.

5. Attention is called to the probability that certain fungi described in the past as growing upon the surface of leaves were really parasitic on scales. This is very likely the case for *Aschersonia*.

6. The ascus-forms nearly all belong to the *Pyrenomyces-Hypocreales*, a group containing the well known entomogenous genus *Cordyceps*. Representatives of eight or nine genera have so far been found on coccids. Thus the entomogenous habit seems a common feature of the *Hypocreales*.

7. The remaining two *Ascomycetes*, *Myriangium* and *Apiosporium*, are of less importance. The former is

\* Guignen, *loc. cit.*, pp. 47 and 50.

doubtfully parasitic and the identity of the latter is uncertain. They are black fungi and one of them is known to follow "honey dew."

8. The forms placed amongst the Fungi imperfecti are probably in the main conidial stages of the Hypocreales. *Microcera* is known to belong to *Sphærostilbe*, and *Aschersonia* to *Hypocrella*.

9. Some of these fungi appear to be restricted to definite kinds of scale-insects. *Nectria* and *Microcera* are confined to the sub-family Diaspidinæ; *Cephalosporium* to species of *Lecanium*; one type of *Aschersonia* to the Aleurodidæ (*Aleurodes* spp.); and another to *Lecanium*.

10. So far fungi have been found on ten distinct genera, and thirty species at least of Coccidæ and Aleurodidæ.

11. The interesting genus *Torrubiella* has only been found on spiders and coccids. It has not been so frequently met with in Ceylon as some of the others, *e.g.* *Nectria*.

12. Several of these fungi that have been tried grow well on various artificial media.

13. Inoculating experiments attempted by the application of watery decoctions of spores to healthy scales have not met with the success expected. The conditions favouring infection are evidently somewhat peculiar and require thorough investigation.

14. The conidia of many of these fungi are probably distributed by rain and ants, and not by wind.

15. The economic importance of these fungi must be kept in view. Some of them have been successfully employed in the United States against noted scale-pests, rendering ordinary insecticides unnecessary. As moisture and warmth naturally favour their growth, Ceylon should be a suitable country for testing their efficacy as a remedy for scale-attacks.

In conclusion, my thanks are due especially to Mr. E. E. Green for much assistance in many ways, and also to Mr. T. Petch for some useful criticism.

Cambridge, November, 1905.

*Postscript.*—A new conidial form from Natal.

While this paper was in preparation for the press, the writer received from the Government Entomologist of Natal a fine specimen of a coccid-fungus distinct from any hitherto examined. It is a conidial form attacking scales of *Mytilaspis citricola* on the stem of a Citrus (?), and was found in Zululand in November, 1905. A cursory examination has revealed the following features. Standing up around the scale are a few whitish bodies, resembling somewhat in general appearance the sporodochia of *Nectria coccidophthora*. Each consists of a short stout brown stalk, surmounted by a broad sub-conical white or cream-coloured head. An average sized one gave the following measurements :—

Stalk, length 0·5 mm., breadth 0·42 mm.

Head, height 0·33 mm., width 0·68 mm.

The stalk is stroma-like in texture, its component parts not separating in water. The head, on the other hand, swells in water liberating conidia. In fact, it consists solely of a mass of a conidia without any sheath or admixture of sterile hyphæ; neither are there any separate fertile hyphæ bearing the conidia. These, in fact, sit upon the broad top of the stalk. They are borne in pairs—occasionally in threes—on the tips of hyphæ which barely project above the general level of the stalk-top. Thus the conidia may be regarded as sessile, the conidiophore being almost suppressed.

The conidia are long and straight, multiseptate with their free ends tapering. The longest measure about  $150\mu \times 8\mu$ , and have as many as 17–20 septa.

The fungus does not seem to fall readily into any of the recognized genera of the Fungi-imperfecti. It seems to have points of agreement with the conidial fructification of *Ophionectria coccicola* found in Java and described by Zimmermann (see p. 27).\*

December 26, 1905.

\* Zimmermann, Centralb. f. Bakt., Abth. II., Bd., VII., 1901, p. 372.

V.—Table of Species with their Hosts, &amp;c.

Fungus.	Insect.	Plant.	Country.	Collector and Date.	Reference.*
<b>ASCOMYCETES.</b>					
<i>Pirenomyces-Hypo-</i>					
<i>cretes.</i>					
Torrubiella rubra, Pat. and Lagerh. ...	Unnamed	Melastoma and Solanum, leaf l.s. ...	Ecuador	—	14
Torrubiella luteo-rostrata, Zimm. ...	do.	Jungle tree, leaf ...	Java	—	21
Torrubiella, sp. ...	Aleurodes, sp. ...	Tetraneura, leaf l.s. ...	Pondalu-oya, Ceylon	Green, 1899	P
Do. sp. ...	do. ...	Jungle tree, leaf l.s. ...	Pussella, Ceylon	Macmillan, 1899	P
Nectria aurantiicola, B. and Br. ...	Aspidiotus destructor, Sign. ...	do. ...	Pondalu-oya, Ceylon	Green, 1899	P
Nectria coccorum, Speg. ...	Unnamed	Citrus aurantium, stem	Ceylon	—	1
Do. coccigena, Speg. ...	do.	Bay tree, fallen leaves	Brazil	—	16b
Nectria coccidiphthora, Zimm. (Conidial stage = Fusarium) ...	do.	Eugenia, sp. leaf ...	do.	—	16c
	Mytilaspis, sp. ...	Coffea arabica ...	Butenzorg, Java	—	21
	Parlatoria, sp. ...	Citrus, sp. ...	...	—	

\* These numbers refer to the bibliography.

V.—Table of Species with their Hosts, &c.—*contd.*

Fungus.	Insect.	Plant.	Country.	Collector and Date.	Reference.
<i>ASCOMYCETES—contd.</i>					
<i>Prenomyces Hypocrea</i> — <i>contd.</i>					
...	Aspidiotus aurantii Mask.	Citrus, sp., stem ; Rosa, sp. stem	R. B. G., Pera- deniya, Punda- lu-o-ya, Ceylon	Green and Parkin, 1898	P
..	Aspidiotus camelliae, Sign.	Osbeckia, sp. stem	Pundalu-o-ya, Ceylon	Green. 1898	
...	Aspidiotus cydoniae, Comst.	Citrus decumana, stem	do.	do. 1898	
...	Aspidiotus phyllanthi, Green	Phyllanthus myrtifolius, stem	R. B. G., Pera- deniya, Ceylon	do. 1900	
..	Chionaspis biclavus, Comst.	Tea and Tabernaemontana, stem	R. B. G., Pera- deniya, and Punda- lu-o-ya, Ceylon	Green and Parkin, 1898	

—	Mytilaspis lasianthi, Green	Codiaeum variegatum, leaf	R. B. G., Pera- deniya, Ceylon	P
Nectria, sp.	Asterolecanium miliaris, Boisd.	A bamboo, leaf u.s.	R. B. G., Pera- deniya, Ceylon	21
Lisea Parlatoria, Zimm.	Parlatoria zizyphi	Citrus, leaf	Java	21
(?) Calouectria, sp.	Mytilaspis citricola, Pack.	Orange, leaf	Avisawella, Cey- lon	P
(?) Do.	Chionaspis vitis, Green	Loranthus, sp., leaf	Horton Plains, Ceylon	21
Opioneectria coccicola (Ell. and Ev.) Berl. and Vogl.	Unnamed	Citrus, leaf	Java	—
Sphaerostilbe coccophila Tulasne (see Microcera coccophila)	—	—	—	21
Broomella Ichneaspidis, Zimm.	Ichneaspis filiformis	Coffea liberica and Elaeis, sp., leaf	Java	—
Broomella Ichneaspidis, var major	One of the Diaspidinae	Pierardia, sp., leaf	Raciborski	21
Hypocrella Raciborskii, Zimm.	Unnamed	Citrus, sp., leaf	do.	—
(?) Hypocrella, sp.	Lecanium expansum, Green	Schumacheria alni- folia, leaf u.s.	Maskeliya, Cey- lon	21
			Green, 1898	P

V.—Table of Species with their Hosts, &c.—*contd.*

Fungus.	Insect.	Plant.	Country.	Collector and Date.	Reference.
ASCOMYCETES— <i>contd.</i>					
<i>Pyrenomyces Hypocreales</i> — <i>contd.</i>					
(?) <i>Hypocrella</i> , sp.	Lecanium hemisphaericum, var. coffee, Wlk.	Gelonium lanceolatum, leaf lvs.	Pundalu-oya, Ceylon	Green, 1898	P
(?) Do.	Chionaspis vitis, Green	Loranthus, sp., leaf	Horton Plains, Ceylon	do. 1900	
(?) <i>Drussiella</i> , sp.	Aclerda distorta	Arundinaria, sp., stem	Pundalu-oya, Ceylon	do. 1899	
<i>Pyrenomyces-Perisporiales</i> .					
(?) <i>Apiosporium</i> (Capnodium), sp.	Aspidiotus perniciosus		—	—	2
<i>Plectasinea</i> .					
<i>Myriangium Duriei</i> , Mont. and Berk.	Unnamed	Coffea liberica and Elaeis, sp., leaf	Java	—	21

Myriangium Duriei, Mont. and Berk. ...	Aspidiotus camelliae, Sign. ...	Osbeckia, sp. stem ...	Pundalu-oya, Ceylon ...	Green, 1898	} P
—	Chionaspis bielavis, Comst. ...	Tabernaemontana, sp. stem ...	R. B. G., Pera deniya, Ceylon	do.	
—	Mytilaspis citricola, Pack. and M. pallida, Green ...	Codiaeum variegatum, leaf ...	do. ...	Parkin, 1899	
FUNGI IMPERFECTI.					
<i>Sphaeropsidales-Nectrioidaceae.</i>					
Aschersonia aleyrodis, Webber ...	Aleurodes citri, R. & H. ...	Citrus, spp., leaf ...	Florida, U. S. A. ...	Webber, 1893 ...	18 and 19
Aschersonia turbinata, Berk (?) ...	Ceroplastes floridensis, Comst. ...	Citrus, spp. and Celtis occidentalis, leaf ...	do. ...	do. ...	19
Aschersonia aleyrodis, Webber (?) ...	Lecanium hesperidum, L. ...	Andropogon muricatus, leaf, l.s. ...	do. ...	do. 1895 ...	19
—	Aleurodes, sp. ...	Ochlandra, sp. leaf, l.s. ...	Pundalu-oya, Ceylon ...	Green, 1898	} P
—	Do. ...	Memecylon capitellatum, leaf l.s. ...	Pussella, Ceylon	Macmillan, 1899	
—	Do. ...		R. B. G., Pera- deniya, Ceylon	Parkin, 1899	

V.—Table of Species with their Hosts, &c.—*contd.*

Fungus.	Insect.	Plant.	Country.	Collector and Date.	Refer- ence.
<b>FUNGI IMPERFECTI—<i>contd.</i></b>					
<i>Sphaeropsidales—Victrioidaceae—contd.</i>					
—	Aleurodes, sp.	... Flemingia strobilifera, leaf l.s. ...	R. B. G., Pera- deniya, Ceylon	Green, 1900	P
—	Do.	... Diospyros Tuposia, leaf l.s. ...	Balangoda, Cey- lon ...	do. 1901	
—	Do.	... Hedyotis verticillaris, leaf l.s. ...	Hakgala, Ceylon	do. 1901	
—	Do.	... Filicium decipiens, leaf l.s. ...	R. B. G., Pera- deniya, Ceylon	do. 1901	
Aschersonia aleyrodis, Webber (?) Aschersonia, sp.	Lecanium, sp., Lecanium psidii, Green	Coffea liberica, leaf ... Myristica moschata, stem and leaf ...	Sumatra ... R. B. G., Pera- deniya, Ceylon	1898 (examined) Green, 1899 ...	
Do.	Lecanium hemisphaeri- cum, var. coffee, Wlk.	Tea, stem, and leaf ...	Upper Assam ...	1899 from Green	P
Do.	Lecanium, sp.	Tea plant ...	Kurseong and Darjeeling, India	1900 and do.	—

<i>Aechersonia</i> , sp. ...	<i>Aleurodes</i> , sp. ...	<i>Eugenia</i> revoluta, leaf l.s. ...	Horton Ceylon	Parkin, 1899 ...	P
<i>Aschersonia</i> sclerotoides, P. Henn.	<i>Lecanium</i> sp. ...	<i>Castilleja</i> elastica ...	Java	Zimmermann ...	9
<i>Hyphomyces-Macdi-</i> <i>nacea</i> .					
<i>Cephalosporium</i> Lecanii, Zimm.	<i>Lecanium</i> viride, Green	<i>Coffea</i> liberica and C. arabica, leaf and stem ...	Java	Zimmermann, 1897 ...	20
—	Do.	C. arabica, leaf and stem and Citrus decumana	Pundalu-oja, Ceylon	Green, 1898 Parkin, 1898	P
—	—	<i>Atalantia</i> Zeylanica, leaf	Kandy, Ceylon...		
—	<i>Lecanium</i> nigrum, Nietn.	<i>Hibiscus</i> rosa-sinensis, stem ...	Pundalu-oja and Kandy, Ceylon	Green and Parkin, 1898	
—	Do.	<i>Anona</i> cherimolia, stem	Pundalu-oja, Ceylon	Green, 1899	
—	<i>Lecanium</i> hemisphaeri- cum, Targ.	Tea plant	Ramboda, Ceylon	do. 1901	4
—	<i>Lecanium</i> hemisphaeri- cum, var. coffee, Wlk.	<i>Jussiaea</i> suffruticosa, stem ...	Pundalu-oja, Ceylon	do. 1898	
<i>Hyalopus</i> Yvonis, Dop. ...	<i>Aspidiotus</i> perniciosus, var. ...	<i>Cocos</i> nucifera ...	Martinique	— 1904 ...	

Fungus	Insect.	Plant.	Country.	Collector and Date.	Refer- ence.
FUNGI IMPERFECTI—contd.					
<i>Hyphomyces-Macedo- naceae</i> —contd.					
<i>Acrostalagmus ocellicola</i> , Guéguen	...	Mikania (?)	...	Paris (green house) France	8
<i>Sporotrichum Lecanii</i> , Peck.	...	—	...	N. America	8
<i>Verticillium heterocladium</i> , Penzig.	<i>Lecanium</i> , sp.	...	...	...	16a
<i>Verticillium</i> , sp.	<i>Lecanium hesperidum</i> , Asterolecanium millaris, Boisl.	Citrus limonum	N. Italy	Penzig	P
<i>Hyphomyces-Dematia- ceae</i> .	...	A bamboo, leaf l.s.	R. B. G., Pera- deniya, Ceylon	Parkin, 1898	...
(?) <i>Pezizotrichum</i> , sp.	<i>Chionaspis aspidistree</i> , Sign.	Palm, leaf	do.	Green, 1899	}
Do.	<i>Aonidia</i> , sp.	<i>Memecylon</i> , sp. leaf	Elephant Pass, Ceylon	do. 1901	
<i>Hyphomyces-Tubercula- raceae</i> .	...	...	...	...	...
<i>Fusarium</i> (see <i>Nectria</i> ). <i>Microcera coccophila</i> , Desm.	...	Salix, Fraxinus, Alnus, &c., stem	France, Italy, Austria, Britain, Belgium	Desmazieres, 1848, and several observers since	3 and 17
<i>Sphaerostilbe coccophila</i> ]	...	...	...	...	...

Aspidiotus perniciosus and A. articulatus, Morgan ...	Citrus, sp. ...	U. S. A. ...	—	5 and 15
Aspidiotus coccineus and others ...	Citrus aurantium ...	Australia ...	Bailey and Maiden ...	11
Aspidiotus aurantii, Mask. and Mytilaspis citricola, Pack. ...	Citrus, sp., stem and leaf ...	R. B. G., Peradeniya, Ceylon ...	Parkin, 1898	}
Mytilaspis pallida, Green ...	Codiaeum variegatum, leaf ...	do. ...	do.	
Do. lasianthi ...	Croton, leaf ...	do. ...	Green, 1900	
Aonidia bullata, Green ...	Nothopegia Colebrooki- ana, leaf u.s. ...	Pundalu-oya, Ceylon ...	do. 1899	
Do. crenulata ...	Menecylon umbella- tum, leaf ...	R. B. G., Peradeniya, Ceylon ...	do. 1899	
Do. sp. ...	Aspidiotus camelliae, Sign. (?) ...	Pundalu-oya, Ceylon ...	do. 1899	}
Do. coccophila ...	Aspidiotus articulatus, Morgan ...	W. Africa ...	1899 examined	
—	Aspidiotus articulatus and Ischnaspis filiformis ...	Grenada, W. Indies ...	Punch, from Newstead, 1898	
—	Fiorinia florinae, Targ. ...	Mauritius ...	From Green, 1899	
—	Camellia, leaf l.s. ...	—	—	

Fungus.	Insect.	Plant.	Country.	Collector and Date.	Refer- ence.
FUNGI IMPERFECTI—contd.					
<i>Hyphomyces-Tubercula- riaceæ</i> —contd.					
<i>Microcera rectispora</i> , Cooke and Mass. ...	Unnamed ...	<i>Citrus aurantium</i> ...	Brisbane, Aus- tralia ...	—	16
<i>Microcera tasmanien- sis</i> , ...	<i>Aspidiotus</i> , sp. ...	<i>Eucalyptus</i> ...	Tasmania ...	Lea, 1901	11
<i>Microcera mytilaspis</i> McAlpine ...	<i>Mytilaspis</i> , sp. ...	<i>Hymenanthera dentata</i> ...	Victoria, Austr- alia ...	McAlpine	
<i>Sterile Forms.</i>					
"Brown mealy fungus" ...	<i>Aleurodes citri</i> R. and H. Do. sp. ...	Orange leaves Memecylon capitelli- tum, leaf l.s. ...	Florida, U.S.A....	Webber, 1896 ...	19
Do. ...	Do. sp. ...	Jasminum Sambac, leaf l.s. ...	R. B. G., Pera- deniya, Ceylon	Parkin, 1899	P
Do. ...	Uncertain ...	<i>Calophyllum Walkeri</i> ...	Yatiantota, Cey- lon ... Horton Plains, Ceylon ...	Green, 1900 Parkin, 1899	

## VI.—BIBLIOGRAPHY.

(The fungus to which each paper particularly refers is placed in brackets.)

1.—Berkeley and Broome : "Fungi of Ceylon," Journ. Linn. Soc., XIV., 1875, p. 117. (*Nectria*.)

2.—Britton : "San José Scale, Natural Enemies in Connecticut," U.S.A. Exp. Station Conn. Report Entom., Part II., 1902. (*Capnodium*.)

3.—Desmazières : "Plantes Cryptogames Nouvelles," Ann. des Sc. Nat. 3rd ser., 1848, p. 359. (*Microcera*.)

4.—Dop : "Sur un nouveau Champignon, parasite des Coccides ou genre *Aspidiotus*," Bull. Scient. de la France et Belgique, XXXIX., 1905, p. 135. (*Hyalopus*.)

5.—Forbes : "Recent work on the San José Scale in Illinois," Illinois Agric. Exp. Station, Bull. 56, 1899. (*Microcera*.)

6.—Fuller : First Report of Government Entomologist. Dep. Agriculture, Natal, 1901, p. 99. (*Sphærostilbe*.)

7.—Gossard : "White Fly," Florida Exp. Station. Bull. No. 67, 1903. (*Aschersonia*, *Sphærostilbe*, and Brown sterile fungus), also "Two Peach Scales," Bull. 61. (*Sphærostilbe*.)

8.—Guégnen : "Les Champignons parasites de l'homme et des animaux." Paris, 1904, 8vo., 317 pp. (General account, *Acrostalagmus*.)

9.—Hennings : "Fungi Javanici Novi a cl. Prof. Zimmermann." Hedwigia, XLI., 1902, p. 140. (*Aschersonia*, 5 n. spp., one on a coccid.)

10.—Hennings : "Die Gattung *Aschersonia* Mont." Festschrift für P. Ascherson, 1904, pp. 68-73.

11.—McAlpine : "Two new fungi parasitic on Scale-Insects," Journ. Agric. Victoria, XI., Part 7, May, 1904. (*Microcera*.)

12.—Maskell : "An Account of New Zealand Scale-Insects," p. 22.

13.—Parkin : "Fungi found in Ceylon growing upon Scale-Insects (*Coccidæ* and *Aleurodidæ*)." Report British Assoc. Bradford, 1900, p. 932.

14.—Patonillard and Lagerheim : "Sur Champignons de l'Equateur," Bull. de la Soc. Mycol. de France, vol. IX., 1893, p. 154. (*Torrubiella*.)

15.—Rofls : "A Fungus Disease of the San José Scale," Florida Agric. Exp. Station, Bull. 41, 1897. (*Sphaerostilbe*.)

16.—Saccardo : Sylloge Fungorum. (a) Vol. IV., 1886, 151 p. (*Verticillium*); (b) Additamenta to vols. I.-IV., 1886, p. 203 (*Nectria*); (c) Vol. IX., 1891, p. 154 (*Nectria*); (d) Vol. IX., 1891, p. 996 (*Ophionectria*); (e) Vol. X., 1892 p. 731 (*Microcera*).

17.—Tulasne : Carpologia, vol. III., 1865, p. 105. (*Sphaerostilbe*.)

18.—Webber : "Preliminary notice of a Fungus Parasite on *Aleyrodes citri*," Jour. of Mycol., vol. VII., p. 363. (*Aschersonia*.)

19.—Webber : "Sooty Mould of the Orange and its Treatment," U. S. A. Depart. Agric., Div. Veg. Physiol. and Pathol., 1897. No. 13. (*Aschersonia* and "brown mealy wing fungus.")

20.—Zimmermann : "Over eene Schimmel epidemie der Groene Luizen," Voorloopig Rapport, 1893, Buitenzorg. Java (*Cephalosporium*.)

21.—Zimmermann : "Einige javanische, auf Coccida parasitierende Ascomyceten." Centralb. f. Bakt. Abth. II., Bd. VII., No. 24, 1901, pp. 872-876 (several genera of the Hypocreales).

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Note on 11.—Saccardo, S. F., vol. xviii., lists these two fungi as *M. tasmanica* and *M. mytilaspidis*, respectively.

## EXPLANATION OF PLATES.

(The figures all illustrate Ceylon specimens.)

PLATE I.

*Torrubiella.*

*Fig. 1.*—*Species 1*: Piece of leaf of *Tetranthera* with large brown stroma on the white mycelial fringe of which are borne deep pink perithecia *p*; also a small stroma without perithecia with central part of scale *s* (*Aleurodes*, sp.), visible.  $\times 5$ .

*Fig. 2.*—Perithecium,  $\times 20$ . *Fig. 3.* Ascus,  $\times 320$ .  
*Fig. 4.* Ascospore,  $\times 320$ .

*Fig. 5.*—*Species 2*: Piece of leaf of a jungle tree with *s*. scales (*Aspidiotus destructor*) without fungus and *p*, perithecia with coherent bases.  $\times 5$ .

*Nectria.*

*Fig. 6.*—Piece of Citrus stem with scales of *Aspidiotus aurantii* attacked by fungus in conidial stage: *s*. scale without and *sf*, one with fungus. Natural size.

*Fig. 7.*—Detached scale of *fig. 6* showing 7 sporodochia (conidial heads) around it.  $\times 10$ .

*Fig. 8.*—Detached scale of *Chionaspis biclavis* showing fungus in ascus-stage. *p*, perithecia; *sp*, remains of a sporodochium.  $\times 10$ .

*Fig. 9.*—Four sporodochia in the dry state, showing various lengths of stalk, *st*; *h*, glutinous heads of conidia; *p*, young perithecia.  $\times 20$ .

*Fig. 10.*—A sporodochium expanded by water which liberates the conidia; *p*, young perithecia.  $\times 20$  (semi-diagrammatic).

*Fig. 11.*—Conidia,  $\times 320$ . *Fig. 12.* Conidiophore; *c*, young conidium,  $\times 320$ .

*Fig. 13.*—Sheath-hyphæ of sporodochium, showing cross-pieces *cp.*  $\times 320$ .

*Fig. 14.*—Perithecium,  $\times 20$ . *Fig. 15.* Ascus,  $\times 320$ . *Fig. 16.* Ascospore.  $\times 550$ .

## PLATE II.

*Fig. 17.*—Nectria on scales of *Asterolecanium miliaris* on piece of bamboo leaf; *s*, scale without fungus; *sc*, scale with fungus on conidial stage; *sa*, in ascus stage.  $\times 2$ .

*Fig. 18.*—Single scale of *fig. 17* with sporodochia, *sp*, and two contiguous scales with perithecia. *p.*  $\times 10$ .

*Fig. 19.*—Ascospores of Nectria of *fig. 17*.  $\times 550$ .

## *Calonectria.*

*Fig. 20.*—Ascus,  $\times 320$ . *Fig. 21.* Ascospores with 4 septa  $\times 550$ .

*Fig. 22.*—Ascospore of another specimen—larger and with 5 septa.  $\times 550$ .

## *Hypocrella.*

*Fig. 23.*—Stromata covering scales of *Lecanium expansum* on leaf of *Schumacheria alniifolia*. Dark dots represent opening of perithecia. Natural size.

*Fig. 24.*—Section through two perithecia showing faintly the filiform asci.  $\times 40$ .

## *Myriangium.*

*Fig. 25.*—Scales of *Aspidiotus camelliae* on *Osbeckia* stem. The dark bodies (perithecia) around the scales represent the fungus.  $\times 5$ .

*Fig. 26.*—Ascus,  $\times 320$ . *Fig. 27.* Ascospore,  $\times 550$ .

*Aschersonia, a.*

*Fig. 28.*—Piece of leaf of a grass (*Andropogon muricatus*) with black scales (Aleurodes) attacked by *Aschersonia*. *s*, scales without fungus; *sp.*, scales partially covered with fungus; remainder *st*, scales completely covered with stromata, the dark dots representing the openings of the pycnidia. Natural size.

*Fig. 29.*—Detached stroma, being the largest one in fig. 28, *h*, hypothallus; *p*, openings of pycnidia.  $\times 5$ .

*Fig. 30.*—Conidia.  $\times 550$ .

*Fig. 31.*—Piece of bamboo (*Ochlandra*) leaf with black Aleurodes attacked by *Aschersonia*. *s*, scales without fungus; *st*, stromata covering or partially covering scales, minute dark dots representing openings of pycnidia. Natural size.

*Fig. 32.*—Detached stroma from fig. 21, side view. *p*, openings of pycnidia.  $\times 5$ .

*Fig. 33.*—Leaf of *Memecylon capitellatum* (underside) with pale Aleurodes attacked by *Aschersonia* and "brown mealy wing fungus"; *b*, pustules of latter; *s*, scales without fungus; *st*, scales covered with stromata of *Aschersonia*, showing hypothallus and openings of pycnidia. Natural size.

## PLATE III.

*Fig. 34.*—Vertical section of stroma of fig. 33; *p*, pycnidia; *h*, hypothallus; *s*, remains of scale.  $\times 10$ .

*Fig. 35.*—Section of stroma of fig. 33, showing *c*, conidial bearer with conidia and *p*, sterile hyphæ (paraphyses).  $\times 100$  (semi-diagrammatic).

*Aschersonia, b.*

*Fig. 36.*—Twig of *Myristica moschata*, showing numerous large stromata covering scales of *Lecanium psidii*. *s*, scales without fungus. Natural size.

*Fig. 37.*—Vertical section of a stroma; *p*, pycnidia, *s*, remains of scale.  $\times 10$ . *Fig. 38*, conidia.  $\times 550$ .

*Aschersonia, c.*

*Fig. 39.*—Leaf of *Eugenia revoluta*. *s*, scale (Alenrodes) without fungus; *st*, stromata over scales with 2 or 3 pycnidia each; *sp*., scales partially covered with fungus. Natural size.

*Fig. 40.*—Uppermost stroma of fig. 39, showing openings to the two large pycnidia, and *h*, hypothallus.  $\times 5$ .

*Fig. 41.*—Vertical section of fig. 40: *p*, pycnidia; *s*, remains of scale.  $\times 5$ .

*Fig. 42.*—Conidia.  $\times 550$ .

*Black Aschersonia (?)*

*Fig. 43.*—Stroma (side view),  $\mu$ , upper part bearing surface conidia; *p*, openings to pycnidia; *b*, thickened basal border.  $\times 5$ . *n*, natural size of stroma.

*Fig. 44.*—Vertical section of fig. 43; *p*, pycnidia; *c*, conidia-bearing superficial hymenium; *s*, remains of scale.  $\times 5$ .

*Fig. 45.*—Conidia.  $\times 550$ .

*Fig. 46.*—Vertical section of another stroma showing *p*, perithecia.  $\times 5$ .

*Fig. 47.*—Perithecium of fig. 46 enlarged, showing faintly the filiform asci.  $\times 40$ . *Fig. 48.* Sporule from ascus.  $\times 550$ .

*Cephalosporium.*

*Fig. 49.*—Piece of leaf of *Aphelandra tetragona* with scales of *Lecanium viride* affected by fungus which is represented by the light areas around the scales. *s*, scales without fungus. Natural size.

*Fig. 50.*—Piece of stem of *Anona cherimolia* with scale of *Lecanium nigrum* affected by the fungus, which is represented by the white part around and upon the scale. Natural size.

## PLATE IV.

*Fig. 51.*—This shows the development of the Cephalosporium from below the scale—only a segment is drawn. *s*, portion of scale ; *c*, conidiophores.  $\times 60$ .

*Fig. 52.*—Branched conidiophores of Cephalosporium.  $\times 320$ .

*Fig. 53.*—Single conidiophore in dry state. *z*, globular head of mucilage in which the conidia are embedded.  $\times 550$ .

*Fig. 54.*—Single conidiophore after treatment with acetic acid. The conidia *c*, are now visible.  $\times 550$ .

*Verticillium.*

*Fig. 55.*—Conidiophore. *c*, conidium.  $\times 550$ .

*Pezizotrichum (Botryotrichum) ?*

*Fig. 56.*—Scales of Aonidia affected by fungus on piece of leaf of Memecylon. *s*, scales without fungus.  $\times 3$ .

*Fig. 57.*—Detached scale with fungus. *b*, sterile bristles ; *m*, conidial mycelium.  $\times 10$ .

*Fig. 58.*—One of bristle-hyphæ showing swollen hyaline tip.  $\times 100$ .

*Fig. 59.*—Part of bristle-hypha more magnified.  $\times 320$ .

*Fig. 60.*—Portion of conidial mycelium. *c*, conidia.  $\times 320$ .

*Fig. 61.*—Conidium.  $\times 550$ .

*Microcera.*

*Fig. 62.*—Piece of leaf containing scales of Aspidiotus affected with the fungus. *s*, scale without fungus. Natural size.

*Fig. 63.*—Detached scale of *Aspidiotus aurantii* viewed from above with 8 sporodochia radiating from margin: *sh*, sheath of sporodochium; *c*, conidial head inside.  $\times 20$ .

*Fig. 64.*—Piece of leaf of *Nothopegia Colebrookiana* with three scales; *sf*, *Aonidia bullata* affected by a *Microcera*; and two scales, *s*, without fungus. Natural size.

*Fig. 65.*—Detached scale from fig. 64. Fungus forms a red stroma *st*, upon peripheral part of the scale. From the posterior extremity projects a single sporodochium; *sh*, its sheath, and *c*, the conical conidial head.  $\times 20$ .

*Fig. 66.*—Conidia.  $\times 320$ .

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